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DRAKE UNIVERSITY MUNICIPAL OBSERVATORY.

By D. W. MOREHOUSE.

The dedication of the new Drake University Municipal Observatory on November 5, 1921, was a notable event in the history of Des Moines. If there were no more to the project than the beautiful and altogether unique building situated in an ideal location, there would be sufficient cause for congratulation. However, the purpose of the enterprise gives it distinction. The idea of a Municipal Observatory is probably not indigenous with Des Moines. It has appeared in some form in a few American cities. The oldest and possibly the most authentic claim is made by Cincinnati. Records show that about 1842, the Cincinnati Astronomical Society bought the famous Mitchel Telescope. This instrument was placed in the Cincinnati Observatory, located in the heart of the city. It was later, 1873, moved to Mount Lookout. In 1903 a larger telescope was purchased and additions were made to the building.

At the dedication of the Mitchel Building of the Cincinnati Observatory, Director J. G. Porter referred to the reputation which Cincinnati has acquired of starting new and untried enterprises, citing the Mitchel Telescope among other examples. He pointed out that "Mitchel in procuring for the people of Cincinnati, at that time a western, frontier city, a telescope rivaling the great Pulkova glass, then the largest in the world, justly ranks as the originator of this progressivism. For although the Observatory was not at first a municipal institution, it was nevertheless erected by and for the people; and the new Mitchel Building designed chiefly for the accommodation of the public, worthily carries out the idea of the illustrious founder of the Observatory."

Oakland, California, also has a Public Observatory established by one of its citizens, Anthony Chabot, and now forming a part of its school system.

The Allegheny Observatory at Pittsburgh, Pennsylvania, founded by Pennsylvania's "Grand Old Man," Dr. John A. Brashear, the famous maker of telescopes, is one of the best known public observatories in the east. He tells the incident that when working in the rolling mills he was permitted to look through a small telescope and it inspired in him a determination to give to the people of Pittsburgh

adequate facilities for viewing the heavens. Shortly before his lamented death, April 7, 1920, Dr. Brashear wrote, "May I say that while I have been interested in scientific work for nearly half a century and have done my best to bring the beautiful things in science to the comprehension of laymen—yes, to boys and girls, in lectures, etc., nothing outside of my purely educational work has given me so much pleasure as the free department of our Observatory, the realization of a dream of my late childhood. The demand is as great as ever to see the beauties of God's universe, and apart from the scientific side, its high *moral* worth counts every time and all the time."

The above facts have been related that there may be no misunderstanding concerning Des Moines' priority in establishing a Municipal Observatory. I doubt if it can be shown that any other city has planned and erected a public observatory in a public park for the primary purpose of giving to its citizens an opportunity to know the beauty, dignity, and high moral value of Astronomy. It is quite true that after some great soul, such as Mitchel, Chabot, Lick or Brashear, has established and demonstrated the civic value of a public observatory, then the municipality or state has supported it, but Des Moines took the initiative.

Some quotations from a few letters just received will indicate the light in which our city is seen by others.

"I extend my hearty congratulations to the city of Des Moines for the liberal and progressive spirit manifested in the founding of an observatory supported by a municipality. May the example of Des Moines be followed by other cities, especially by those that have a university in their midst."—Dr. Otto Klotz, Director of Dominion Observatory, Ottawa, Canada.

"I heartily congratulate the city of Des Moines on the installation of a municipal observatory. I have been pushing the idea of a municipal observatory for several years. On November 21st I am to lecture before the College Club in Chicago and am to put in some propaganda on a municipal observatory."—S. B. Barrett, Yerkes Observatory, Williams Bay, Wisconsin.

"I heartily congratulate all concerned in the building of the Drake University Municipal Observatory. It is in every way such a splendid achievement. The co-operation between University and city which it symbolizes, is one of the finest things about it. Oakland, as you know, has the Chabot Observatory as a part of its school equipment, but this is exclusively a city enterprise. Berkeley has its student observatory, but this is exclusively a university institution. Your observatory belongs to University *and* city and hence should hold the interest of both as well as serve both. You are to be heartily congratulated."—Dr. Robert G. Aitken, Lick Observatory, California.

The University of Toronto, Canada, is now in a campaign to establish an astronomical observatory for Toronto. In a pamphlet

recently issued by Professor C. A. Chant, setting forth arguments for such a project is the following:

"In Des Moines, Iowa, (population 86,000 in 1910) Drake University has a telescope of aperture of eight and one-fourth inches. The public department of this institution has become so popular that a separate observatory, especially for the citizens, has been erected and is open to the public several evenings each week."

Dr. George E. Hale, Director of the great Mt. Wilson Solar Observatory at Pasadena, California, the home of the world-famous one hundred inch Hooker telescope, writes, "Hearty congratulations on the initiation of this admirable plan."

The architecture of the building was given more than usual consideration. Two of our leading firms of the city co-operated most effectually in giving to it more significance than is usually found in a building of this character. Its design presented a problem consisting of elements different from those usually confronting an architect. From the architectural point, our first desideratum was to use such features as would indicate that various ancient nations had contributed to the science of Astronomy. Realizing that only a few could be indicated, it was necessary to use those features with discretion in order to obtain a harmonious result, and as architecture is a conventional art, they must be so combined as not to interfere with the general design.

The building is a massive structure of gray Bedford stone and the architecture is classic of the severe Grecian type. As one approaches the building, a sun dial is seen directly in front of the main entrance, thus leading the observer by an easy and natural step to reflect upon the importance of the sun to our planet. On six stone panels of the pilasters, on either side of the door, the signs of the zodiac, carved by hand, attract the eye and further direct the mind to consider the relative position of the earth, sun and surrounding firmament. The historical significance of these signs is of great interest and their origin of great antiquity. The top unit of each pilaster is a Greek Corinthian capital which suggests the contributions which Greece made to the arts and sciences. Carved in Roman letters on the lintel is "Drake University Municipal Observatory" and directly above this is the familiar bas-relief of the winged sun with attendant cobras, used so frequently by the Egytians on their architectural monuments. On either side of this carving are two dates indicating the age of the building, the one on the west is the Roman date, J. E. 6633, indicating in astronomical lore the Julian epoch and the one on the east, 1920 A. D., the common Roman name for the year of our Lord. Thus in review before our minds pass the ancient Chaldean, Persian, Egyptian, Greek and Roman civilizations, each of which contributed its part to the science to which this building is dedicated.

From a mechanical point of view, the building is also worthy of note. It has acquired the name of the "honor job" in Des Moines. It seems as if each workman took special pride in contributing all

that his art could give to this historic project. The stone work is especially fine, as all observers admit. A hollow space is left between the outer and inner walls throughout the entire building, thus doing away with a feature which is usually troublesome in stone buildings, that is, of moisture penetrating the walls and affecting the decoration. The building is fireproof. There is a very complete basement containing public rest rooms, a fine photographic room, a room designed for a seismograph and an automatic oil-burning heating plant. Owing to the structure of the walls mentioned above, these rooms are as dry as if they were above ground.

On the ground floor the main entrance is into a beautiful rotunda. The conventional representation of our solar system is depicted in marble in the sky blue mosaic floor. The suspended ceiling is dome-shaped and gives a realistic representation of the celestial sphere. The decoration was given considerable thought. It is a sky blue and blends most beautifully with the surroundings.

Opening from the rotunda to the west is the transit and clock room. On the east is a delightful office, while to the north is the gem of the entire building, a public lecture room and library. Extending around the walls of this room are racks containing a most interesting collection of photographic transparencies through which light shines giving a very fine representation of the celestial objects as seen through the telescope. The book cases are quartered oak in flat finish. The walls are a greenish buff.

The observing room is just above the rotunda. The telescope is mounted on re-inforced concrete beams resting on the extra heavy stone wall and insulated from possible vibration by compressed cork. These are the only points of contact between the telescope and the building. The interior walls of the observing room are of pressed brick, a soft shade of gray. The lights are recessed, allowing free movement of the observing chair and giving an indirect method of lighting. The dome is eighteen feet in diameter and covered with copper. This makes a beautiful exterior effect, especially in the fall when the various colored trees are reflected in the variegated colors of the oxidizing copper. There is thus afforded a strikingly appropriate home for the graceful and remarkably efficient nine-inch telescope.

Extending around the exterior of the observing tower is a balcony with an iron balustrade, opening into the observatory by four doors and on to the roof of the lecture room, which is finished with promenade tile and gives an admirable opportunity for entertaining large groups of people with naked eye observations.

The equipment of the observatory consists of a nine-inch Warner & Swasey equatorial with optical parts by the John A. Brashear Company; a five-inch photographic doublet, a nine-inch photographic lens of 120-inch focal length and a standard spectroscope, all by the same firm; a transit instrument by an English firm, chronograph,

PLATE III.

DRAKE UNIVERSITY MUNICIPAL OBSERVATORY.

ENTRANCE TO DRAKE UNIVERSITY MUNICIPAL OBSERVATORY.

chronometer, sextants, and in short, practically all of the usual apparatus used in Astronomy.

The observatory is open to the public without charge, on Monday and Friday evenings from 7:30 to 9:00. Visitors are entertained by the staff with lectures, explanations and direct observation through the telescope. Wednesday evenings are reserved for clubs and public schools by appointment. The observatory has been open for one month and we have entertained something over seven hundred people during this time. The interest seems to be growing and the attitude of the people is extremely gratifying.

LARGER WORLDS.*

By F. R. MOULTON.

It would not be inappropriate on this happy occasion to devote ourselves to praise of the undertaking which has led to the erection of this splendid building. It is the fulfillment of a twenty-year dream. In its physical aspects it matches the high ideals of those who have changed this dream into realities. Many complimentary things could be said with full justice about Dean Morehouse and the public-spirited citizens who have given him their efficient support. This would not be an unprofitable use of our time because we are always benefited by considering successful and unselfish efforts of our fellow men.

Let us recall that it was observations of the heavenly bodies that ways had the effect of lifting men from their immediate neighborhoods to broader things. A view of this lovely park and its glacial hills from the balcony of the bronze dome above us gives one a thrill; but a glimpse through its telescope of the universe which stretches out beyond our tiny world will fill him with inspiration. We shall not be contented, therefore, to consider the present occasion in its local connection alone, but rather we shall attempt to set it in the background of some of the noblest achievements of mankind.

Astronomy has always stimulated men to discover larger worlds—larger physical worlds, larger intellectual worlds, and larger moral worlds. We shall consider the subject briefly in these three aspects and in this order; and then we shall be better able to interpret the present occasion.

Let us recall that it was observations of the heavenly bodies that first led men in ancient times to believe that the earth was spherical; that gave Columbus the courage to hold his mutinous sailors under control for many weeks while they sailed across unknown seas; and

*Address delivered by Professor F. R. Moulton, of the University of Chicago, on November 5, 1921, at Des Moines, Iowa, at the dedication of the Drake University Municipal Observatory. From a stenographic report by Frank C. Walrath.

that even now enable navigators to determine the positions of their ships at sea.

Astronomical observations were an essential factor in the methods that have been employed in measuring the diameter of the earth. But the determination of the earth's dimensions was only the first step on a path which has led to dizzy heights in our knowledge of the physical universe. With the earth as a base-line, astronomers have measured the distances to the moon, sun, and planets. The volumes of these bodies have been computed, their masses determined, and the laws of their motions established. Although the earth has been found to be of great size, its volume is only a small fraction of that of the other planets, and less than one-millionth of that of the sun. And, similarly, with the distance from the earth to the sun as a base-line, astronomers have sounded the depths of those vast regions which contain millions, and even hundreds of millions, of stars—all of them suns and many of them far greater and more brilliant than our own.

In considering stellar distances, the mile is not a suitable unit just as an inch would not be in measuring continents. Astronomers use rather, the distance light travels in a year, although the length of the path it describes in one second is greater than seven times the circumference of the earth. The stars we see above us at night average in distance, perhaps one hundred light-years, while the countless smaller ones revealed by telescopes are usually so far away that thousands if not tens of thousands of years are required for their light to come to us. Even in this unit, descriptions soon cease to have much meaning to our weak and untrained imaginations, and we replace understanding by a formula. The best glimpses we get of the truth are obtained by contemplating such facts as that there are aggregations of stars varying from a few thousand to more than sixty thousand in number —the globular clusters—which form relatively tiny units in our stellar system, but which are nevertheless so vast that the distances between their individual members are comparable to fifty thousand times the distance from the earth to the sun. Until modern measurements determined, with some approximation, the dimensions of our stellar system, no one in all the history of the race, neither astronomer, nor philosopher, nor theologian, ever dreamed in the wildest flights of his fancy that the whole physical universe is so vast as one of these clusters.

Astronomy has not only brought within the range of our knowledge worlds of great size and inconceivable numbers, but worlds of equally diverse characteristics. Our nearest neighbor, the moon, presents in its barren and desolate surface striking contrast to the verdure-clad earth, and shows what our planet would be like if it were not for the water and atmosphere which surround it. The planets beyond—Mars, Jupiter, and Saturn—have canals, belts, or rings, and several of them are attended by a number of satellites. The sun is a glowing mass of gas whose temperature is several thousand degrees above

the highest that has been produced in our laboratories. Under the extreme conditions prevailing on its surface, great storms rage in which masses of matter many times greater than the earth in volume are hurled about with velocities even as great as several hundred miles a minute. Sometimes masses of glowing gas are thrown from its surface to a height of half a million miles.

Discoveries which were later found to be of importance on the earth have been made in studying the celestial bodies. For example, helium, so named because it was first found on *helios*, the sun, is an element of remarkable properties. Its discovery on the earth was a direct consequence of knowledge respecting its spectrum which had been obtained by analyzing the light of the sun. One of its properties is that, next to hydrogen, it is the lightest gas. Another is that it does not readily unite chemically with other elements. For these reasons it is very valuable for use in balloons, both because it is buoyant and because it is not explosive. Helium would have played an important part in the late war if it had continued a few months longer, for this element had been found to be abundant in certain gas wells. Before the armistice was concluded, it had been separated from other gases and collected in large quantities for use in observation balloons. The sun's magnetic field, the solar corona, the luminosity of nebulae, the variability of certain stars, the sudden and temporary appearance of others—these and many other phenomena are assisting in the solution of the immensely important problem of the constitution of matter. In fact, astronomers are using the whole visible universe as a laboratory for the determination of the fundamental properties of matter and energy so that Nature may be more largely controlled for our benefit.

Astronomy has opened up to men larger physical worlds—worlds vastly larger in mass, dimensions, and space occupied, larger in their diversity and complexity, and larger in the avenues they give to the secrets of nature. But much more important than these things are the larger intellectual worlds which have been at the same time unfolded. Every physical discovery has made new demands upon the mind, sometimes in imagination, sometimes in reasoning, and sometimes in the construction of theories. Many of the results are permanent achievements of the human race, redounding to its glory and contributing to its welfare. Let us mention a few that stand out particularly.

The fundamental principle on which all science is based is that the universe is orderly. It is not axiomatic that natural phenomena succeed one another in systematic sequence. The ancients accounted for what they saw by assuming that mountains and streams and springs are the dwelling places of capricious gods and goddesses who interfered both in the inanimate world and in human affairs. The reason they failed to discover the uniformities in the universe is obvious. Nature is so complex that it is not easy to perceive the order that underlies its manifestations. Since there was no obvious cause for storms in the

sky, they were ascribed to a god on cloudy Olympus. And, similarly, it was supposed that earthquakes were produced by the turning over of a restless giant who slept beneath its surface.

The first steps in perceiving that the universe is orderly were the most difficult, if not the most important. They were taken in Astronomy because such of its phenomena as the succession of the phases of the moon are conspicuous enough to attract attention, are not so frequent as to become commonplace, nor so infrequent as to be forgotten, while the regularity and simplicity of their sequence can hardly be matched elsewhere in nature. The ancients were so deeply impressed by the regular recurrence of these phenomena that they used them as a guide for the times of holding their religious ceremonies.

It is not a very difficult step from celestial phenomena to terrestrial phenomena. If the former are orderly it was reasonable to suspect that the latter might be. Observation and experiment confirmed the suspicion. The foundation of science was laid and subsequent generations of men have been building the superstructure. To astronomy have been added the other physical sciences—physics, chemistry, geology, etc.—the biological sciences, and the humanities. It is impossible to state or conceive of the extent to which science has changed the mode of living of the human race. A century, or even much less, has seen the world revolutionized. Countless machines, our slaves, work for us and produce the necessities and many of the luxuries of life with only a relatively small effort on our part. The corresponding mental and moral changes are taking place more slowly. What is needed now even more than an extension of science in its physical applications is the dissemination of its spirit. The world is sadly in need of its sincerity, of its fundamental honesty, and of its altruism.

One of the most complete, coherent, and practically important body of theories in the world is that of mechanics which rests primarily upon the laws of motion. They were discovered by Galileo and Newton from considerations of the motions of the moon and planets. The simplicity of the movements of the celestial bodies, which describe their orbits under the ideal conditions of a vacuum and relatively few forces, enabled these great scientists to lay the foundations for all of dynamics. If the sky had always been overcast, it is doubtful if we should yet have taken the first steps in mechanics. Quite aside from the applications of dynamics, this doctrine has been of the highest importance to mankind because it is a model which cannot be surpassed in the soundness of the inductions on which it rests, the perfection of the organization which it presents, or the uses which have been made of general principles. What could call forth better mental activities or inspire in one a greater faith in the power of the human mind than the original prediction and verification of the return of Halley's comet, or of the existence and posi-

tion of Neptune from its slight cumulative effects on the orbit of Uranus? And it should be remarked in this connection that the recent doctrine of relativity was initially inspired by Michelson's observations of the stars, and that all the crucial tests of it which have been so far suggested are astronomic in character.

The development of the doctrine of evolution, which was widely accepted in the last decades of the nineteenth century, was undoubtedly the greatest intellectual movement of all time. This doctrine completed science itself in a fundamental respect. As has been remarked, the basis of science is the orderliness of the universe. The doctrine of evolution maintains that the order of today came out of that of yesterday in a continuous and orderly manner, and that it will go over into that which will exist tomorrow in a similar continuous and orderly manner. In a word, the doctrine of evolution is that the universe is orderly in time as well as in space.

Consider how the doctrine of evolution has changed the thought of the world. Whether we contemplate a star, a continent, a mountain, an animal, a political tenet, a philosophical creed, or a theological dogma, we think of it in connection with the antecedents out of which it has grown, we trace out its relationships in space and time to other similar things, and we look forward to its development in the future. Every natural object, inanimate or animate, every product of the intellect, and every fear, hope, and aspiration has roots reaching back in time as well as out in space. The doctrine of evolution directs attention to causes and consequences. A physiographical feature becomes the passing result of geological factors; an animal, a link in a gradually changing life-stream; human history, a continuous current rather than a catalogue of isolated events. As the laws of change become known it becomes possible to look into the past beyond rocorded history and even beyond the human race itself. Similarly, it becomes possible to foretell what will happen in the future, not only for short intervals during which the predictions may be verified, but also for times so remote that the human race will have become extinct. When the past developments of mankind are contemplated this doctrine is one of hope and not of despair. It becomes at once possible, if not probable, that improvements in the future will be as great as those which have taken place in the past, and man is even given courage to attempt the direction of his own evolution.

Whence comes this new point of view which is changing the thought of the world? It had its vague beginnings among the brilliant Greeks but it was buried in the mysticism of antiquity. In its present form it is modern. One hundred years ago geologists still believed that the earth had been visited from time to time by great cataclysms that destroyed everything on its surface. Animal and plant forms were supposed to be fixed. The human race was supposed to have back of it a history of only a few thousand years and to be at present

the degenerate descendants of perfect ancestors. But more than one hundred and fifty years ago the doctrine of evolution was boldly applied in astronomy, first by Wright, and then by Kant. The stars were so remote and impersonal that inherited prejudices did not prevent free speculation. Wright and Kant were followed by Laplace in 1796. His great name and fame as an astronomer gained wide acceptance for his views. He outlined a theory of the origin and development of the earth. His hypothesis gave geologists a basis for their theories and paved the way for Hutton's Uniformitarianism in 1830. This theory, that all the geologic features now on the surface of the earth are the results of the actions in the course of millions of years of such forces as are now operating, was widely accepted by geologists. These ideas in turn prepared the way for Darwin's *Origin of Species* in 1859. It is seen that the development of the doctrine of evolution has been from Astronomy to Geology, and from Geology to Biology. Together these sciences give a picture of a sweep of events which has not been approached in any fiction. It is clear, therefore, that Astronomy has led to larger intellectual worlds in some of the most important achievements of the human mind.

Man has a moral world, though it cannot easily be defined. It consists, at least in part, of his general philosophy of the universe and his own place in it. A philosophy of life and living, if it may be spoken of in this way, is not limited to philosophers, or to the educated. It is a common possession of mankind. Even a thief has his "code." Men order their lives in harmony with their philosophy, for to do otherwise would be to them a discord. This is the reason that it is so important. It is, in fact, what is meant by character.

Now a man's philosophy depends in part upon his inherited characteristics and in part upon the totality of his own intellectual experiences. The inherited characteristics are due to the experiences of his ancestors. Consequently the philosophies of men depend upon the intellectual experiences of the race. Even in the case of an individual they are numerous and varied, and their separate effects cannot be determined. They are not obtained alone in schools or study, for the sight of the sea, or mountains, or sky is often fully as important. Men have always been impressed by the starry heavens. When they still believed that the stars were only jewels on a crystalline sphere they were moved to some of their noblest sentiments. The works of the sacred and classic writers abound with passages expressing the inspiration produced by a glimpse of the sky on a cloudless night. And when scientific measurements succeeded vague speculations the inspiration was only increased. If the first result was to make men feel their own insignificance, it was presently succeeded by a pride that they were a part of so wonderful a universe. They were lifted out of the pettiness of their own lives and became in their own minds, as well as in reality, parts of a magnificent creation.

The character of astronomical work is such that it has had pro-

PLATE IV.

THE OLD PENDULUM DRIVING CLOCK, NOW DISCARDED.

Photographic Telescope U. S. Naval Observatory.
(From west side.)

found effects upon those who have pursued it, and it has modified the lives of those who have simply found pleasure in it as an occasional pastime. There has never been anything in it that is mean, or low, or sordid. Success in it has not been at the expense of someone's failure or defeat. Its victories have never caused a widow, an orphan, or an aching heart. Its object has been only the truth. The very atmosphere of such a subject inspires one to lofty purposes.

Astronomy has made another and still more important contribution to the philosophy of men. It gave not only the first, but the most abundant and convincing proofs that the universe is orderly. What could be more striking than Newton's explanations of the numerous peculiarities of the motion of the moon on the basis of the law of gravitation, or the fulfillment of the prediction of eclipses, or the discovery of Neptune from its effects on the orbit of Uranus? The motions of the binary stars establish the empire of the law of gravitation in distant parts of space, while the spectroscope proves that the remote stars are composed of the same materials as our sun, and, indeed, as those which make up our own bodies. And in it all there is found no accident, no chaos, no violation of law. Nothing happens without an adequate cause, or antecedent, and every cause is followed by a definite result. And so it is with ourselves physically, intellectually, and morally, for we are a part of the universal order.

I congratulate you on having completed and equipped so splendid a building. It is an ornament to your city. But I congratulate you more for having made easily accessible to your citizens larger worlds, physical, intellectual, and moral. Those of them who are mature in years and have experienced the trials and disappointments which are common to mortals will have their courage and faith renewed by views of the serene heavens through the splendid telescope which is mounted in the dome. Those who are young in years will find here a stimulus for their imaginations and support for their highest ideals.

THE NEW ELECTRIC DRIVING CLOCK OF THE PHOTOGRAPHIC TELESCOPE OF THE U. S. NAVAL OBSERVATORY.

By GEORGE HENRY PETERS.

(Communicated by Captain W. D. MacDougall, U. S. Navy, Superintendent.)

The driving clock of the 26-inch equatorial telescope as originally installed at the old Naval Observatory is described and illustrated in the volume of the Washington Astronomical and Meteorological Observations for 1874. This volume also contains a description and illustrations of the 26-inch instrument, as previously assembled at the former location.

The subsequent conversion of the mechanical parts of this equatorial mounting into a photographic telescope, and the construction for use on this instrument of a pair of photographic triple lenses of 10 inches aperture and 113 inches focal length was described by me in POPULAR ASTRONOMY, Vol. XXVII, No. 6.

The old 26 inch driving clock has been employed until recently in the photographic observations made with this latter instrument. These observations have been mostly of minor planets, for position. In this work it has been necessary to guide accurately upon a star for periods ranging generally from half an hour to an hour and a half, and occasionally more. The micrometer of the guiding telescope has been used mostly in these observations to allow for the motion of the minor planet with respect to the stars during the period of observation. An annunciating clock operating an electric buzzer once per minute gives the signal for each micrometer setting. Tables have been computed, using as arguments daily motions in α and in δ. One of these tables gives the proper micrometer interval in divisions of the micrometer head for any probable daily motions. The other table gives the position angle setting required of the micrometer for the ranges of motion usually found in the ephemerides of these minor planets.

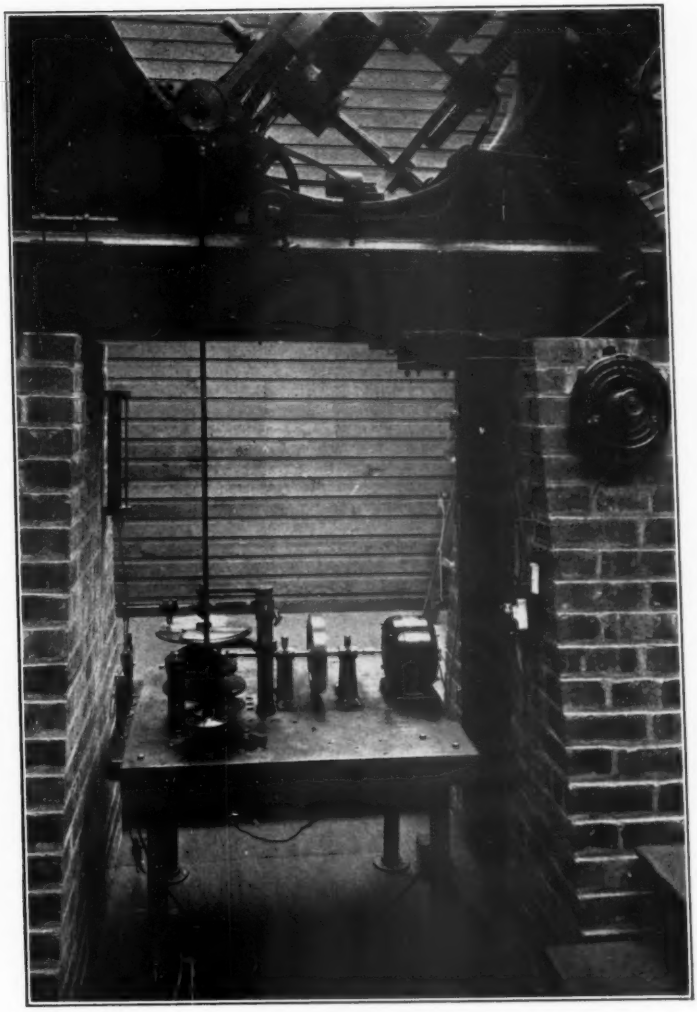
The old driving clock had been improved after its installation with the photographic telescope. The motive power for winding was a 1/6 h. p., a. c., Emerson motor. The motor pulley drove a large pulley on the winding frame through a small round leather belt. These pulley ratios were about one to four. This second pulley had a pinion wheel attached to its axle, which in turn drove a large spur wheel below it. To the axle of the latter gear the winding drum for the endless clock belt and its weights were attached.

By means of suitable pulleys the direction of the clock belt was changed as required to function properly. The Emerson motor was rated at 1750 revolutions per minute, while the spur wheel and winding drum performed 28 revolutions.

There were two serious defects in this mechanism. First, the leather winding belt of the clock and the smaller belt from the motor, had the habit of breaking occasionally. This fiasco generally occurred near the middle of the photographic exposures, rendering the observations valueless. The other defect was the loud, discordant noises produced while the driving clock was in operation. This discord was caused by the vibrations of the rapidly revolving pinion wheel in the spur wheel. The fact was, everyone in the vicinity could tell when the photographic telescope was in operation from the sounds produced. The noise made by the clock winding machinery was of such a nature that even the buzzer signal of the annunciator clock required attention, not to miss it.

In operation, the main clock weight of this recently discarded apparatus was arranged as previously at the Old Observatory, with

PLATE V.



NEW ELECTRIC DRIVING CLOCK

Photographic Telescope U. S. Naval Observatory.
(From west side.)

the Huyghens loop for continuous winding. This weight was made to break the electric circuit, cutting off the motor upon reaching the proper elevation. When the momentum of the motor, which was belted to run a trifle fast for the clock, was expended, the larger driving weight fell to a slightly lower level. This descent re-established the electric circuit to the motor through the automatic switch. This cycle was then repeated while the clock was in operation.

It had been found advisable recently to employ a stronger magnet to operate the electric brake on the old clock, which much improved its dependability.

A 3/16″ round leather belt was substituted for the endless cord as originally used. This substitution also effected some improvement in the running of the driving clock.

The winding drum and the pendulum shaft pulley were both equipped with conical spur projections on the tread. These latter, holding the clock cord rigidly, prevented a sufficient degree of freedom in the pendulum.

The 3/16″ leather belting was made to ride to one side of these spurs. This arrangement gave sufficient slip on the pendulum rod pulley to allow the conical pendulum to function more freely. With these and several minor improvements the old driving clock usually performed fairly well, and at times excellently. However, one could never depend upon it with certainty:—See Washington Astronomical and Meteorological Obs. 1876, Part I, p. XCII. It seemed to have the faculty of knowing when the observer took his eye away from the ocular, either to set the micrometer or to rest his eye. Improper guiding causes errors in the measured positions of objects, especially if comparison stars of different magnitudes are employed. The eye fatigue of the observer, following a fair night's work, was considerable. A constant vigilance was necessary, both in detecting, and correcting with the slow motions of the telescope any departure of the star image from the guiding wires. Small guiding errors become easily apparent, as a guiding telescope of 9.6 inches aperture and 172½ inches focal length with a power of 400 is used in making these observations.

I had been considering the adaptation of a new driving clock to this photographic telescope for several years. The question was, what type of clock to employ. The gravity clock has much to recommend it, especially those designed and constructed by the Warner and Swasey Co. This type of clock, with the centrifugal pendulum, is easily rated and maintained in adjustment by the regulating weights of its conical pendulum. It requires, however, a considerable space for the driving weight to fall. This space was not available conveniently in this photographic telescope, in which the clock at its base is but slightly above the level of the ground. Moreover, the gravity clock is liable to run down during long exposures, if its weight is not automatically wound up by a motor, as occasion requires.

For several years I had thought much about electrically driven and

self controlled driving clocks, with the idea of adapting such a one to the photographic telescope. The conditions sought were reliability, simplicity and durability. I could not then see how to design such a clock with a simple mechanical regulator for the alternating current motor. Recently, however, the ideas came to me, and these have been incorporated in the new electric driving clock for this photographic telescope, now to be described. The principle upon which the new driving clock is constructed, and its mode of operation, are briefly as follows.

The 1/6 h. p., a. c., Emerson motor, which furnished power for winding the weights of the old driving clock, now discarded, is retained. This motor, operating free, rotates about 1750 times per minute. The motor, through an attached shaft, is made to turn a worm-screw of six threads per inch, having a diameter of about 7/8 inches. This screw, properly aligned, engages in a worm-wheel having 124 teeth. The worm-wheel is mounted upon a vertical shaft in a properly designed frame having three upright supporting posts. Two of these posts 90° apart, act respectively, one as a support for the worm-screw, and the other post for the attachment of the lifting arm which is hinged to it, and which serves to make and break the circuit to the motor by proper devices and adjustments. The third post acts simply as a support for the frame.

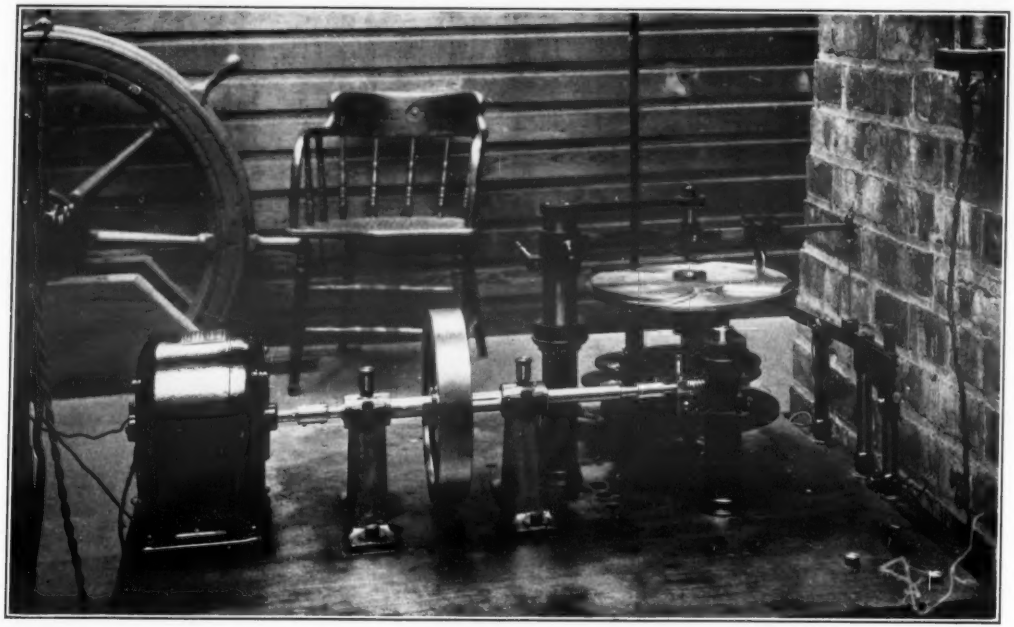
Above the worm-wheel, and also horizontal, is a circular bronze table 10 inches in diameter. This table is attached to, and revolves with the vertical shaft. Upon this table is securely clamped a metallic plate, which rotates with it.

This plate in outline is symmetrical in figure with respect to the radius of the axis of rotation. It is of such a form that a variable part of the arc on the radius, at different distances from the center of motion, is interrupted by the lifter-wheel attached to the lifting-arm. As at present arranged the circuit is *broken* by means of this lifter-wheel or cam, where the plate elevation occurs.

The lifting device, or arm, consists of an approximately square rod, which is channeled out on its under side to reduce its weight. Upon this rod a movable stop is mounted, and also a movable wheel attachment, or carriage. Both of these parts are provided with set-screws for use when the proper position on the arm has been attained. When the lifter-wheel is placed on the lifting-arm as near the center of rotation of the turn-table as the adjustments allow, the current of the motor is cut off by the automatic switch, which will be described later, for the longest period of time.

When the turn-table with its lifter-plate is revolved by the motor and worm-wheel, the arc on the radius of interrupted current decreases, as the wheel carriage is moved outward. This position of the lifter-wheel on the lifter-plate, therefore functions as a mechanical regulator, to automatically control the speed of the motor, and consequent-

PLATE VI



NEW ELECTRIC DRIVING CLOCK

Photographic Telescope, U. S. Naval Observatory.
(Detailed view from east side.)

ly the rate of the driving clock. As this position can be varied as above described the clock can be easily and accurately rated.

The wheel-carriage and lifting-arm are so arranged that the wheel does not rotate except when in contact with the lifter-plate. The lifter-plate does not extend quite to the edge of the turn-table. By placing the wheel-carriage temporarily out to a screw stop on the lifting-arm, an uninterrupted current is obtained for starting the motor. The movable stop above described allows the wheel-carriage to be brought back after starting, to the proper position for isochronism.

Between the motor and the worm-screw is a 20-pound bronze fly-wheel. This fly-wheel is very accurately balanced, and keyed to the shaft. It is mounted between two upright iron brackets, where the shaft runs in babbitted bearings. The thrust of the shaft is principally taken up at these positions.

Between the shaft and the worm-screw is a universal joint. Suitable oil-cups are provided along the line of bearings, from the motor to and including the worm-screw. The vertical revolving shaft bearings are oiled through conveniently located tubes.

The vertical shaft, besides the turn-table and worm-wheel, also carries the first wheel of the clock-train, containing 160 teeth.

This shaft at its base turns in a cylindrical bearing. The pressure thrust is taken up by a ball bearing at the base of the shaft.

Between this large gear wheel on the rotating vertical shaft and the next gear of the clock train an idler of 72 teeth is introduced. This idler allows the use of gears with different numbers of teeth on the next element and also assists in securing good pitch contact. In turn, the idler engages the third wheel of the clock train.

This latter gear is attached to a ½-inch vertical rod, which extends upwards to the original gearing on the "harp-shaped piece" of the equatorial mounting of the telescope.

The gears of 160 and 72 teeth came originally on the clock base of the instrument as constructed by the Clarks. On the new electric clock the original positions of the second and fourth gear wheels of the old driving clock have been reversed, to allow for the high speed of the motor. The rotation of the gear and worm-wheel now attached to the vertical shaft of the motor driven parts is in the opposite direction from that of the pendulum of the old clock. The gear attached to the pendulum shaft of the old clock was discarded in the new construction.

The cast iron base upon which the old pendulum clock was mounted has been retained, and upon this base the new electric clock is erected. This base is about 30 inches square, with a top planed level. The edges lap down about 2¾ inches, and are also machined. The under side of this base had been cast with a recess to reduce its weight. This casting, in the photographic telescope's pendulum clock, was set into the wooden flooring beneath the pier, which was independent of the

floor of the observing building. The casting was thus placed close to the concrete base which carries the two separated brick columns of the pier. The "harp shaped piece" of the telescope rests upon these brick columns, with the driving clock beneath. In the new electric driving clock the square iron base has been elevated about two feet above the floor by iron pipe supports.

These supports are of 2-inch pipe, and located one at each corner of the base. They are bolted to the under side of the base through flanges threaded to the pipe. Similar flanges at the lower end of the pipe are screwed to the flooring. The electric clock is thus convenient to operate, and besides, is removed from the dust and dirt of the floor level. The present arrangement is such that it can be covered for protection when not in use. If deemed necessary, the clock can be covered-in permanently with side doors, for convenient access.

A clutch was introduced on the upright driving rod which extends from the last wheel of the clock, to a bevel gear on the "harp shaped" part of the mounting. This clutch allows the last wheel of the clock to turn the upright rod, or to run free, and can be connected or disconnected easily at will. It serves as a safe-guard, or can be used to stop the telescope, and allow stars to trail for orientation purposes at the end of an exposure, with accuracy as to time. With the great amount of energy developed in the clock by the motor and stored in the fly-wheel, a clutch of this kind becomes absolutely essential. Especially is this the case in the present equatorial mounting, where a sector is used. If this sector should happen to run out, a quick disconnection of the clock would become necessary to prevent damage.

The electric circuit breaker, or automatic switch, is modeled on a principle similar to that finally adopted to control the motor driven winding attachment of the rotating pendulum clock just discarded. It is much more elaborate, however. This circuit breaker is mounted on a block of ash of substantial proportions which is bolted to the northern edge of the cast iron clock base. The wood is thoroughly shellacked to secure insulation. Upon this wooden support three substantial brass posts are erected. A flat brass arm, with its greatest width vertical, operates in connection with these posts. This arm is hinged by a pivot to the western-most brass post, allowing a vertical motion. The post at the east is surmounted by a holder, which supports a short cylindrical rod of electrolytic copper. A carbon rod can be substituted for the latter if desired. Longitudinal and rotational adjustments are possible with this holder, to secure fresh contact surfaces on the rod without renewal. Above this electrode, on the eastern end of the flat brass arm, a cylindrical piece of carbon is also secured in a holder. This carbon rod is capable of adjustment in a vertical direction to allow for wear, after which it can be firmly clamped in position. The reciprocal motion of the flat brass arm,

PLATE VII

GREAT STAR CLUSTER IN PERSEUS, NOVEMBER 22, 1921.

Exposure $1^h33.^m6$, with the New Electric Driving Clock.

actuated by the lifting-arm of the clock through suitable mechanism, makes and breaks the current to the motor, at regular predetermined intervals. The middle brass post of the three above mentioned is slotted at the top, and acts merely as a loose fitting guide for the brass arm of the circuit breaker. This arm is practically horizontal, and located several inches below the lifting-arm and the rotating table of the clock.

The connection between the lifting-arm and the circuit breaker is made through a small vertical steel rod. At the lifting-arm this steel rod has a screw adjustment operated by wing-nuts. At the bottom this rod engages in a suitable block of "bakelite," which is attached to the arm of the circuit breaker and acts as an insulator. The bakelite is slotted where the vertical rod is attached to it. This slot is below the upper surface of the bakelite block. It is reached by a small vertical hole drilled for the passage of the rod. A wrist-pin or "cross-head" on this rod allows a slight freedom of motion in a vertical direction in the circuit breaker arm. This "lost motion" prevents the electric contacts from excessive hammering, and also provides a short range of automatic adjustment for the contact surfaces. Swinging ball joints are provided where necessary, to render the apparatus flexible, but without loss of accuracy in functioning properly.

The construction and design of the above described parts is such that the motions are magnified by leverage, from the lifter-wheel to the contact points on the circuit breaker. The lifter-wheel and carriage are raised about 1/8 inch by the lifter-plate, while the contacts separate at least half an inch. This adjustment can be changed while the clock is in operation by a screw nut support for the lifting-arm, which limits its descent when the lifter-wheel is free of the rotating table.

Contacts to the motor from the electric circuit breaker are made through the outer brass supporting posts of this apparatus. Passing the wires through borings in the ash block partially conceals them. A shunt circuit is employed across the circuit breaker, so that a part of the current is always on the motor while it is operating. A carbon filament lamp, with a red glass bulb, furnishes the resistance required in this circuit. The lamp is located in a receptacle beneath the equatorial mounting, where it is inconspicuous. This same shunt arrangement was used on the motor circuit of the winding attachment of the previous driving clock, to steady the motor and reduce the spark at the contacts.

In the new electric clock this shunt arrangement gives a more smoothly running motor, and consequently a steadier clock rate. By unscrewing the red lamp in its socket the shunt circuit can be cut out at any time if desirable. A switch, short circuiting the current on the contact arm, has lately been introduced.

By this arrangement the motor can be started without changing

the position of the wheel-carriage on the lifting-arm. As soon as full momentum has been acquired the short circuit is cut off by the switch. The current is then controlled by the breaker arm circuit, and the motor rate is again regulated by the devices and methods previously described.

Considerable experimentation was necessary to secure the best form for the lifter-plate for the accurate control of the motor. Finally, the problem was worked out geometrically, and several of these plates were made to secure the exact control required. These conditions were that equal changes of position of the wheel-carriage on the lifting-arm should produce equal and refined corrections to the clock rate, and that the wheel-carriage should occupy, normally, a position half way out on its adjustable range on the lifting-arm.

New gears of 78 and 80 teeth respectively were found desirable, eventually, to replace the gear of 72 teeth, the next beyond the idler on the clock train. This latter gear upon testing out the telescope on the stars was found to drive much too fast, and beyond the range of control of the motor. This contingency had been anticipated in designing the new electric clock. A computation from a series of micrometer observations with the guiding telescope of the instrument showed that a gear of about 79 teeth would probably be the most satisfactory size. This odd number of teeth being difficult to cut, it was decided to make one each of 78 and 80. These latter gears were o be easily interchanged, so that the most efficient rate of motor speed could be attained for proper control, and consequent accurate driving of the telescope. In testing out these new gears by guiding on stars, it was found that either of them could be used satisfactorily. The lifter-plate, however, had to be of slightly different design for each case. On the whole the gear of 80 teeth proved the most reliable. With this arrangement a star could be kept bisected by a micrometer wire for a considerable period. It was found by observation that the motor rate fluctuated slowly at times, as the power or pull on the line of the commercial current varied. This minor variation is corrected by a rheostat in the motor circuit, though it is but seldom required.

In designing this electric clock it is best that the motor should run at nearly normal speed, but a trifle fast. The excess speed is then reduced by mechanically cutting off the current to the motor, as previously described, together with the secondary, delicate, variable adjustment with the rheostat. The advantage of the rheostat is that corrections can be made to the clock rate by simply turning a handle. A change in the position of the wheel-carriage on the lifter-arm will of course, give the same results. Both of these adjustments can be made with the clock in operation.

The illustrations accompanying this article will give a fair idea of the general arrangements of this new electric clock. A photograph of the old pendulum clock, now removed, is included for

comparison. Permanent wiring and switches had not been installed at the time the photographs were made.

A plate of the "Great Clusters in Persons" taken November 22, 1921, with an exposure of $1^h\ 33^m.6$, is included, to show the accuracy of drive obtainable with the new electric clock. The original negative was made with one of the pair of triple lenses, of 10 inches aperture and 113 inches focal length, attached to this photographic telescope. The region shown is an enlargement of the central part of the negative.

During the exposure the slow-motion of the instrucent in α was used but little. The slight variation of clock rate required, due to changing refraction, was regulated by small changes of position of the lifter-wheel on the lifting-arm,

The principle of this new driving clock is extremely simple. If desirable a secondary control by a pendulum clock, to obtain a more reliable rate, would be feasible. This auxiliary control, from the experience of the writer, is hardly necessary, as the results without it are eminently satisfactory. The mechanical construction of this type of driving clock is so easy that many equatorial telescopes, now without driving mechanism, might be equipped with this form of motive power. The alternating current, however, is required, which synchronizes the motor. In commercial lighting systems this is the usual form of current supplied. The gear arrangements probably would have to be modified somewhat to meet the electric or instrumental conditions obtaining, but this could be predicted and allowed for in advance of construction. It is likely that a commercial worm-wheel and gears could be used if desirable in the construction of this class of apparatus.

The main features of this electric driving clock were designed by me. I wish here, however, to express my acknowledgements to Mr. J. Rheinbold, the foreman of the nautical instrument repair shop of the Naval Observatory. By careful attention to mechanical details involved and to the delicate adjustments required, he has produced a driving clock of the first quality. I am also indebted to his skill and ingenuity for many of the detailed refinements and modifications introduced as the work of construction proceeded.

HOW TO LOOK AT THE MOON.

By JULIAN L. COOLIDGE.

"The Moon is dead, long live the Moon!"

The first part of this sentence represents pretty accurately the attitude of almost all professional astronomers toward our satellite, the second shows the reaction of a certain number of enthusiastic amateurs who continue to find interest in its study. There are today

competent observers with large telescopes, and there are observers of the moon, but the competent observers do not study the moon, and the selenographers are usually neither competent, nor provided with first class instrumental aid. The reasons for this state of affairs are not far to seek. It is an axiom among most professional astronomers that the moon is dead, that nothing ever happens there. Astronomy, like religion, is more interested today in the living than in the dead, consequently the astronomer can make better use of his time and his instrument than to devote them to the study of a cold, inert planet.

It is not my business to call this axiom into question, to ask whether it is based on careful observation, or is merely what the theologians used to call an argument "e consensu gentium". It represents a perfectly definite attitude of mind among astronomers, an attitude which seems to me regrettable. For whether the moon be lifeless or not, it is certain that, except for its topographical measurements, we know very little about it. There is no semblance of a generally accepted theory as to its origin and formation. It once was hot, and now is cold, that we know pretty well. But whether the formations on it were caused by bombardment, or eruption, or contraction with tidal strains, or a combination of these causes, remains a perfectly open question. We are equally in the dark as to its surface temperature. Some astronomers believe that this always remains below — 100° centigrade. Brown[1], following Langley, puts the maximum around 0° centigrade, but Newcomb[2] maintains that Langley's results really point to a maximum of about 100°. This would seem to have some bearing upon the question of whether Fauth[3] is right in believing that it is coated with ice, or Pickering, when he finds signs of a low type of vegetation.[4] Our beautiful companion seems openly to mock us by flaunting her various features, and challenging us to explain them. Until, however, the skilled astronomer and astrophysicist seriously accept the challenge, the only way that interest may be kept up is by the tentative gropings of the amateur, and to such an amateur the present paper is addressed.

If what you seek in studying the moon is a better acquaintance with the Man, or the Woman, or the Rabbit, or a better knowledge of the composition of the green cheese, then your only requisite is a lively imagination. But if you are looking for something more prosaic, then there are two desiderata: a proper spirit, and a proper instrument. The first of these is the more important and the less common.

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[1] Encyclopedia Americana.
[2] Encyclopedia Britanica.
[3] "The Moon in Modern Astronomy," 1903.
[4] See various recent articles in POPULAR ASTRONOMY, and "The Moon," New York, 1903.

A proper spirit. There seems to be a curse laid upon observers of lunar or planetary detail, which leads them into "envy, hatred and malice, and all uncharitableness." Every lawyer knows that if two equally competent and conscientious observers witness exactly the same occurrence, they will certainly report upon it differently. It is a psychological phenomenon of everyday occurrence. But astronomers can not, or will not learn this lesson, with the result that the usual attitude of mind is this:

"If another observer, with equally good opportunities, sees less than I do he is incompetent, if he sees more he is a nature faker. If he sees the same amount, but sees it differently, he has both attributes." If anyone doubt the prevalence of this attitude, let him make a careful study of the writings dealing with the markings on Mars, from Schiaparelli's first announcement to the present time. It is beside the point to inquire who is primarily responsible for this, the spirit in which the problem of Mars has been handled is not a credit to astronomy or astronomers. And we find traces of the same thing in writings about the moon. The worst offender is—well, never mind, he has studied the subject long and carefully, and written interestingly thereon, but he expresses himself thus:

"I have penetrated into the features of the moon to an extent that no other eye has done."

"The transatlantic observers are hardly in advance of those of Central Europe—This is clearly seen from Prof. Holden's application of the 36-inch Lick refractor to the regions of Hyginus and Aristarchus. The 8 pictures obtained in 1889 are very faulty and poor in detail—In the past few years Professor W. Pickering has explored the region of Messier with his powerful instrument but with, in the opinion of German selenographers, just as little success."

"We may say, in fact, that the object depicted by Pickering does not exist at all. The American astronomer only shows that he has approached the subject without sufficient preparation."

"We may repeat that the announcements from America, which usually command such confidence, on account of the size of the instruments employed, have not yet made any appreciable contribution to our knowledge of lunar conditions."

This was written some time before the War. Fortunately it did not represent a universal German opinion.[1]

Another point about which astronomers dispute is the excellence of their eyes. The pleasant writer whom we have quoted above does not explain the fact that he "has penetrated into the features of the moon to an extent that no other eye has done" by the possession of any remarkable instrument, (he used apertures of 6½-inch and 7-inch) or any unusual site for his observatory (he was 400 feet above sea

[1] See the discussion between Klein and Pickering in Sirius, 1901, 1902, and 1904.

level), but by the excellence of his eyesight. I have seen dreary physiological arguments to prove that the eye which is best for planetary detail is structurally the opposite from that which is most successful in studying nebulae, or comets.[1] I confess to have been as little convinced as I was by a recent statement of Pickering's that there was no such thing as an unusually good eye. Such things entirely surpass my competence; I only know that a prominent oculist told me that in all his many years of practice he never examined another eye that was as good as that of Percival Lowell. I say this without raising the question of whether Lowell only saw with the carnal eye, or occasionally used the eye of faith also.

It is an axiom in logic that positive evidence is of more value than negative. When the Flagstaff observers report that they have seen certain phenomena on Mars with 18-inch or a 24-inch aperture, such statements are deserving of greater weight than that of Antoniadi to the effect that he could see none of these things with a 33-inch aperture in the poor conditions at Meudon.[2] Why not believe both statements? Lowell's contention that he has found in practice that even with the good seeing at Flagstaff, it is better to stop the objective down to 18 inches should carry more weight than Antoniadi's obiter dictum that a reduction of aperture is always a mistake. But it becomes a delicate question just how far to carry this principle. A number of years ago several independent observers reported that they had seen clouds in the tiny lunar crater Taquet.[3] Kritzinger[4] dismissed these accounts as untrustworthy because he had frequently examined the same regions with a 10-inch aperture, as well as with a smaller one, and never witnessed the phenomena mentioned. Here the balance of probability is on the negative side, for Taquet is only three or four miles across, and the other observers used only 3-inch or 4-inch apertures. But the question should be looked upon as still open. The same is eminently true as to the question of the darkening spots on the moon's surface. I mean by this, spots which become darker as the sun rises higher upon them, and fade out again towards sunset. Pickering has given more study to this phenomenon than any other observer[5] and is so convinced that they are signs of vegetation that he speaks of them quite casually as such. This opinion is far from being widely accepted, and Pickering's vegetation theory is usually treated with very scant courtesy. Once more, the proper attitude is one of expectation and suspension of judgment. The difficulties in the way of believing in the existence of vegetation on the moon are so tremendous, as to seem next to in-

[1] Lowell in POPULAR ASTRONOMY, 1905.
[2] POPULAR ASTRONOMY, 1913.
[3] Sirius, 1911, 1912.
[4] Sirius, 1914.
[5] Annals of the Harvard Observatory, Vol 32 and "The Moon" cit., as well as various articles in POPULAR ASTRONOMY.

superable; but it is a question of accepting a bad explanation, or no explanation at all, for it helps us not in the least to say that such a darkening effect is merely a result of conditions of illumination, without saying what those conditions are. Under just what conditions will increased illumination make something look darker? My personal opinion is that this apparent darkening of certain patches, which any amateur can study if he will, is merely a constrast effect, owing to the fact that nearby regions increase more markedly in brightness, and this view is by no means original.[1] But it is at best a very lame attempt to account for what takes place, for I have not been able to reproduce the phenomena under laboratory conditions, and Neison, in his book on The Moon,[2] expressly states that attempts to explain the darkening streaks in Plato on this hypothesis have signally failed.

What is the lesson of all this to the amateur? Be very patient, and very modest, and critical of your own observations. Do not criticise others who see what you do not, or do not see what you do. Do not rush into print as soon as you think that you have observed something new. Observe it continually, under all possible conditions, and read up the literature as far as you can. The chances are that if it is new, it is not really there, and if it is really there, it is not new. But if you surely have seen something interesting, do not hesitate to put forth your results discreetly for fear of astronomer A; you will have no difficulty in finding an equally distinguished astronomer B to tell you that A knows nothing about the moon anyway.

A proper instrument. There has been a good deal of random discussion of just how large a telescope can be profitably used for planetary detail in different climates. This discussion has a very real scientific importance, but is of little interest to the amateur of limited means. In general you will see more with an opera glass than with the naked eye, and more with a prism glass than with a Galilean one, and more with a spy glass than with a prism and so on. Not much detail can be observed with an astronomical telescope of less than 2½-inch aperture, but from there up to perhaps 8-inch every increase in diameter will be advantageous. After that point, or some point in the neighborhood, increased magnification is only desirable if the seeing conditions be really good. It is also true that the excellence of the objective or mirror is quite as important as its diameter.

The books on elementary astronomy are not very helpful as to the technique of lunar observation. There are many such books, most of them excellent; and if there are not more amateur astronomers in the world, it is not for any lack of helpful texts for the beginner. Yet

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[1] See Klein, Sirius, 1887.
[2] London, 1876, p. 246.

the technical instruction given in these works is usually devoted to questions of double star observation, or testing the excellence of the objective. I do not feel sure that the writers are always wise in this latter particular. The tests of an object glass by observing a bright star in and out of focus are excellent for laboratory conditions, but under the prevailing conditions in most climates, the image will bubble and boil and do a lot of things except what you want it to do. As for testing an object glass by trying to separate double stars down to Dawes' limit, that becomes practical when the observer has had some experience, but the beginner is sure to fall into the mistake of trying such things on clear crisp nights, after a day of northwest winds, with results that will disappoint him bitterly. Moreover the point which books for beginners insist on in season and out of season is that the observer should under all circumstances use the lowest possible magnification that will show him anything at all of what he wants. The late Kelvin McKready in his "Beginner's Star Book"[1] repeats this lesson at every opportunity. Now on principle this is a good thing to insist on, for the beginner has the utmost difficulty in convincing himself that the higher magnification does not always show more, but like all other general rules, it has perfectly definite exceptions, especially when applied to the moon. In this matter I am very far from wishing to dogmatise. In advocating the use of high powers when possible, I realize that I am running counter to the opinion of various authorities.[2] The only wise plan is to have a variety of eyepieces and to try them again and again to see which produces the best result under the circumstances. Probably different eyes have different preferences. Mädler is said to have used a power of 300 on a 4-inch objective, 75 to the inch, which certainly seems excessive[3] but it seems fair to assume that such an experienced observer did so because he found the results better than with other magnifications. My own experience has been with a 5-inch refractor, and I have obtained best results, when the seeing was really good, with a magnification of 50 to the inch of aperture; when the air is "jumpy" I cut down to 38 or 25 to the inch. I do not give these figures for any a priori reason. I do not believe that the best magnification is necessaryly proportional to the aperture any way, for a 3-inch instrument, under most atmospheric conditions, will do better with a magnification of 100 than a 15-inch one will with a magnification of 500. I only

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[1] New York, 1912.

[2] Fauth, loc. cit., says that he never exceeds 30 to the inch of aperture, and Kritzinger, loc. cit., says that a low powered eye piece is necessary for sharp color contrasts.

[3] Fauth, loc. cit., p. 15. Neison, loc. cit., states that he used a 6-inch refrector and 9¼-inch reflector, yet he gives plates based on magnifications of 450 and 600, the former being quite sharp in detail.

give my experience for what it is worth, and as a result of repeated experiment.[1]

I find two advantages in this high power. To begin with, I am convinced that I see more. This may be an illusion, but it is at least based on experience. The second is that the high power is much easier on the eye. Here is the essentially new feature in lunar observation, as compared with stellar. The whole field is bright, and with any telescope of more than 2-inch aperture, the amount of light coming in from the moon may be so great as to be positively painful. Now by increasing the power of the eyepiece, the portion of the moon's surface covered is reduced, and with it the total amount of light received.

This reduction of eye strain seems to me of first importance, not only for preserving one's vision, but also for seeing well. The eye is the last lens in the train which begins with the objective, and if this one function badly, it throws out the whole system. Consequently, the amount of light taken in by the eye must not be enough to be blinding. One method, as pointed out above, is to increase the magnification, but I find it wise in practice, to employ other means to this end as well, especially when not using the highest power. How shall we reduce the amount of light entering the eye? The most obvious way would be to stop down the objective with a diaphragm, but this is unadvisable, for, after all, if we are examining one minute object on the surface of the moon, we want all the light we can get *from that particular object*. A still worse plan would be to reduce the eye-hole to very small dimensions, as this blurs the image through the effect of *diffraction*. A third plan would be to screen with a piece of amber glass at the eye end. This I confess I have not tried although Kritzinger recommends it.[2] It seems a priori that any such device would reduce the light where one did not want to reduce it, and destroy the sharpness of color contrasts. How then can the amount of light be reduced? By reducing the field where the image is formed, namely in the eyepiece. The size of the field depends upon the size of the hole in the stop between the two lenses, in a Huyghenian eyepiece, and by decreasing the size of this hole, the amount of light taken in can be reduced to any extent. Personally, I have two little slits opposite to one another, cut in the curved surface of the eyepiece, just above the stop. A thin strip of brass with perforations of different sizes is slid through these slits, and the size of the field depends upon which of the perforations is centered on the axis. I have not found any harmful effects from this method of reducing the field, and it is a very real relief to the eye.

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[1] Since writing the above, I have confirmed my observation with repeated use of a 6-inch. The latter instrument is, however, much harder to please in the matter of seeing, and will allow 50 to the inch much less often.

[2] Loc. cit.

Of course there are disadvantages connected with any proceeding, however useful in general, and there are three inevitable drawbacks to cutting down the field in lunar observation. The first is that the object you are examining gallops across at a distressing speed. This is of no account if the telescope be driven by clockwork, but if not, it may become serious. Under the circumstances, the amateur will be very glad indeed if he be the possessor of an equatorial mounting. A word on this subject. The European telescope makers seem wedded to the idea that the amateur should use an alt-azimuth mounting, and if the price do not seem high enough, they add to the cost by attaching two slow-motions. The equatorial mountings they make are always provided with circles and are correspondingly costly.[1] Even McKready goes wrong on this point, as he writes,[2] "The alt-azimuth is less expensive, as well as less complicated than the equatorial, and it is adapted, if well made, to all the ordinary needs of the amateur." This is true as long as the amateur has never tried anything else: if he has ever used an equatorial, he will never wish to go back to the other type of mounting. Our American telescope makers are well inspired in putting on the market simple equatorial mountings of comparatively reasonable price; one maker going so far as to write: "The vexatious inconvenience of the altazimuth mounting, when used for celestial observations, has led us to discard it from our productions."

The second disadvantage attendant on the reduction of the field is that it precludes the study of such interesting features as the system of rays. This must be frankly acknowledged, and when such studies are undertaken, one must reduce the light by colored glass, use of a solar diagonal, or some other device.

The third disadvantage, which might not immediately occur to the reader, may be really a blessing in disguise. If the field be very small, and if you are not tolerably familiar with the moon's features, you will frequently find, on first looking through the instrument, that you do not know where you are. Time and again, when the moon is tolerably full, the first view will be a bright patch, with no outstanding feature, nothing that you recognize; you will be completely lost. It will be necessary to go over to the terminator, and examine it for some familiar feature, and then make your way back as well as you can across country to the spot which you wish to look at. This dilemma will be, however, an advantage in the end, if it drive you to study photographs and charts of the moon, and to learn the names of as many lunar features as your patience will stand. Many books on popular astronomy have lunar charts, and similar charts of a more elaborate nature are to be found in books on the moon, such as those

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[1] The only exceptions I know to this rule are the Société d' Optique et de Mecanique de haute precision; and Zeiss, for instruments not over three and one-half inches in aperture.

[2] Loc. cit. p. 107.

of Neison or Elger.[1] These charts are useful to a certain extent if you are already familiar with the objects which they undertake to depict, but the beginner will find very little help from them in identifying new objects. Much better is the "Carte pittoresque de la Lune" by Leon Fennet.[2] This really looks a good deal like a photograph, and costs only a few francs. The Gallicisation of the names is a bit confusing at first. One is surprised to see "Golfe dela Rosée" where he would expect "Sinus roris." The best photographs ever taken of the moon are, beyond a peradventure, those made with the Hooker telescope at Mt. Wilson;[3] unfortunately they are only three in number. The excellent series made some twenty years ago at the Yerkes Observatory is also very incomplete, and the projected lunar atlas undertaken at the Lick Observatory was never brought to completion. The best complete photographic atlas is that of C. Le Morvan, published by Themas. More accessible for Americans is Pickering's "Photographic Atlas of the Moon," published in his book, "The Moon,"[4] and in Vol. **51** of the Annals of the Harvard Observatory. The scale of these photographs is much smaller than that of the Paris series, but they are better arranged, and show each lunar feature under five different illuminations. It is certainly rather a dull spot to pore over lunar photographs, murmuring such incantations at "Theophilus, Cyrillus and Catharina," "Hipparchus, Hind, Halley, and Horocks," "Orontius, Huggins, Nasireddin, Saussure, and Miller," but you will find great pleasure in identifying on the moon features whose names and aspect you have already learned from photographs, whereas, conversely, the only way to consult the literature as to interesting features you have observed with the telescope, is to *know accurately by name* the regions where they lie.

And lastly. Begin by learning the whole moon as thoroughly as you can. It will take a long time if you live in a climate where there are many clouds, and if your evenings are often occupied. After that, pick regions which seem particularly interesting and study them intensively. The best view of any particular spot is obviously obtained when it is near the terminator, but if you are studying a spot intensively you must look at it continually under every possible illumination. This is especially the case if you are studying one of the darkening regions. Now and then there will come periods of exceptional seeing. They will be rare, perhaps not more than a few hours in a year; but make the most of them, for you will see more at such times than in all the others combined. And do not fail to draw from your study the two great lessons which astronomy teaches—patience and reverence.

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[1] "The Moon," London, 1895.
[2] Published by G. Themas, 44 Rue Notre Dame des Champs, Paris.
[3] One was reproduced in POPULAR ASTRONOMY, 1920.
[4] Cit.

A FEW FACTS FOR THE METEOR OBSERVER.

By RUFUS O. SUTER, Jr.

Meteoric astronomy offers for the amateur a broad and fascinating field of research. It enables him, without equipment and without technical knowledge of astronomy, to do valuable work for science. Given good eye-sight, a true desire to fathom the enigmas of nature, and patience to work under the starry sky for several hours, his observing outfit is complete. One who has the interest to do this work will soon wish a more extended knowledge of meteors. For this purpose the following article has been written.

On some clear evening in August or November when many meteors are falling, chart the paths of fifteen or twenty of them with regard to the fixed stars. It will readily be observed that most of the meteors seem to diverge from one point in the heavens. If their trails are produced backwards, they apparently meet in a definite small area of the sky. This area is the radiant. Mainly for the calculation of the position of these radiants, their movements, if they have any, and their characteristics, are meteoric observations made. Comparatively few radiants are known with precision. Their movements are in many cases a matter of question. Take, for instance, the Orionids which fall from October 12 to 30. Dr. Olivier, a well known American astronomer, has found that their radiant partakes of motion. On the other hand, Mr. Denning, England's foremost meteor observer, believes it stationary.

Radiants are the effect of perspective. Meteors of each stream travel parallel to each other. As they approach us, their paths apparently open out, in the same manner as rail-road tracks seem to separate before us when we pass along them. A radiant's position accurately determined, it is possible with certain other data, to compute the orbit of that stream of meteors.

Though doubtless many meteors are visitors from far out in space, the greater number of them travel in orbits around the sun. These orbits are of as great ellipticity as the orbits of comets, and lie at all possible angles to the ecliptic. The path of the Leonids is inclined 17 degrees. Meteors are scattered evenly around their entire orbit, or lie along a greater or less arc of it, called the gem. The Leonids occupy so long a gem that it requires two years for them to pass the sun. The Perseids obviously are continually passing the sun.

When earth interferes with the gem of a meteoric orbit, a brilliant display takes place. When we pass through an orbit along which meteors are more evenly scattered, we also encounter a shower; but one of far less brilliancy.

Many groups of meteors travel opposite to the planets; so that

when these collide with earth, their velocity compounds both their real motion and the motion of earth. This is the case with the Leonids, which apparently enter our atmosphere at the rate of 44 miles per second. Since earth is traveling toward them 18¼ miles per second, their real velocity is considerably less. Other meteors, for instance the Andromedes, travel in the same direction as the planets, though somewhat faster. They must overtake earth. Hence, their velocity, when they enter the atmosphere, is comparatively slow —not more than 8 or 10 miles per second. The average real motion of meteors lies between 7 and 26 miles per second.

Meteors are most conveniently classified according to size. Detonating fireballs are the largest. They explode with such tremendous force that they are visible in daylight, and are audible for miles around. Often fragments of them strike our planet's surface in the form of stone or iron falls—according to the composition of the original body. Ordinary fireballs and bolides present similar phenomena, except that they are not audible. Shooting stars are a common sight. They are of all magnitudes—some being telescopic objects, and others, rivaling in brilliancy, Jupiter and Venus. Physically, they are no larger than shot. The greater meteors, however, often reach the weight of many tons.

Including telescopic meteors, over 200 million celestial missiles enter our atmosphere every 24 hours. The human race would soon be pelted to death, were we not protected by the practically impassable shield which nature has provided for us.

Many cometary orbits agree with meteoric orbits; so that it is evident that some meteors, at least, are remains of "extinct comets." Other meteors are companions of comets, and travel with them, imprisoned by their attraction until they are overcome by the more powerful attraction of a planet or sun. The orbit of the Perseids agrees with that of Swift's comet (1862 III). The Leonids have some connection, probably, with Tempel's comet (1866 I). The Bielids are the remains of Biela's lost comet. The meteors of Aquarius are closely connected with the Orbit of Halley's comet. Dr. Olivier, with the observations of the American Meteor Society, has discovered that the May-June meteors of 1916 agree with the Pons-Winnecke comet. Other meteors are the remains of ancient nebulae—for a few are independent of any stream or shower. The theory has been advanced, though now generally discredited, that some meteors were hurled from terrestrial volcanoes in prehistoric days. It has also been suggested that a few have found their origin in the lunar cataclysms.

According to M. Stormer, the famous Norwegian scientist, our atmosphere extends into space over 312 miles. If this is accurate, meteors must fall a great distance through it before they ignite. The following table gives an idea of the altitude of meteor trains:

	Height begin	end
Swift fireball	85 miles	50 miles
Slow fireball	86 miles	25 miles
Slow fireball (radiant near horizon)	59 miles	48 miles
Swift shooting star	81 miles	56 miles
Slow shooting star	63 miles	49 miles

These estimates are average. The durability of meteors is also dependent on their constitution, and on the angle at which they strike the atmosphere. Without doubt many meteors pass through a section of the atmosphere and resume their flight in outer space, none the worse for their encounter with earth.

Warren, Pa.

A MEMORIAL TO ELIAS COLBERT.*

By CHARLES H. TAYLOR.

The Chicago Astronomical Society has lost by death its most valuable member, and, remembering with gratitude the princely gifts of J. Young Scammon, J. B. Hobbs, and others who contributed so liberally of their wealth towards the purchase of our telescope and the erection of the two observatories in which it has been installed, still, having in mind length, variety and quality of service, it must be said that in all its history of nearly sixty years no member has done more for its welfare than Elias Colbert, whose loss we mourn today.

Elias Colbert was born in the City of Paris, April 23, 1829. In the following year his father, whose loyalty to King Charles X had aroused the hostility of the French revolutionists, was forced to flee from his native land. With his wife and infant son he sailed for England. The vessel in which he took passage was shipwrecked. The father was lost but the mother and babe landed safely and she placed him in the care of friends in Birmingham. Here he attended school, grew to manhood, and married, becoming so attached to English customs and English traditions, and so identified with the English people, that he, as well as others, almost forgot that the name he bore had been famous for generations in the annals of France, and that he first saw the light under the standard of the House of Bourbon. Upon the outbreak of the Crimean War in 1854, he joined the British army and was wounded in the battle of Inkerman.

Soon after the close of the Crimean War, his wife having died, he came with his infant daughter to Chicago in 1857, and at once began his life work as a journalist. Though he began as a reporter on the staff of one of the city newspapers, his amazing capacity for hard

*This memorial was presented to the Chicago Astronomical Society at its annual meeting on July 7, 1921. The author, Mr. Charles H. Taylor, for many years Secretary of the Society, died on December 25, 1921.

work soon brought promotion, and during the early part of the Civil War he was Commercial Editor of the Chicago Times. Before the close of the war, he left the "Times," and became connected with the Chicago Tribune, of which he was successively City Editor, Commercial Editor, and Editorial Writer upon Astronomy and other scientific subjects. He was an intimate friend of Joseph Medill, the "Father" of the Tribune, and his advice was often sought and highly prized by that great newspaper man.

Elias Colbert's journalistic work brought him into contact and acquaintance with Abraham Lincoln, Stephen A. Douglas and many other prominent men of the stirring days preceding the Civil War, and during that conflict—men whose names are a part of the history of our country.

But amidst the engrossing duties of his chosen profession, he somehow found time to acquire a marvelous fund of general information which made him a cyclopedia of reference to his friends upon almost every subject of human interest. To those subjects in which he took special delight, he took pains to become particularly proficient. He possessed in an eminent degree, the faculty of intense and prolonged application and concentration of thought, and with it there was combined an exceedingly retentive memory. But the greatest marvel of his career is, that he was able, in those busy early years, without help so far as known, to master the higher mathematics and qualify himself to fill acceptably the responsible positions to which he was soon afterwards called.

His talents would have won for him position and fame in almost any path into which he might have directed them. He published (1868) the "Historical and Statistical Sketch of Chicago," which was the first reliable story of the early commercial development of the Western Metropolis; and every subsequent historian has been compelled to consult its pages for many facts and figures not elsewhere obtainable. His story of the Great Conflagration of 1871 is perhaps the best account of that calamity that was written. He was an honored member of the Chicago Historical Society, and he did enough in this field to prove that he could have excelled in it if he had chosen to devote his talents to historical research and the writing of history.

He was a remarkable linguist, and not content to read and speak other tongues than his own, he pursued, with the thoroughness characteristic of the man, every root to its origin.

Even for music he had a fondness and considerable aptitude.

But the absorbing passion of his life was astronomy, and he is, and always will be, best remembered as teacher, writer and lecturer in this important department of knowledge.

It is impossible to say whether he was one of the original members of the Chicago Astronomical Society, because all our early records were destroyed by the great fire of 1871; but upon the reorganization of the Society in 1874, he is referred to in the minutes of the meeting

of April 16th of that year as Emeritus Assistant of Dearborn Observatory, indicating that he had served as Assistant Director for a considerable period prior thereto. This meeting also passed resolutions commending him "for his active, great, and intelligent service in promoting the success of the Observatory."

April 15, 1875, he was made a Life Member of the Society "as a mark of the high appreciation of this Society for his labors in adding to the list of members, and collecting money to repair the dome of the Observatory." At a meeting of the Directors held July 26, 1875, he resigned his position as Honorary Assistant Director of the Observatory, and was elected Secretary of the Society, a position to which he was re-elected annually for several years thereafter. On the 11th of May, 1876, he was elected a Life Director "in recognition of the value of his services to the Society." On the 30th of May, 1885, he was elected Vice President, and on the 27th of May, 1890, he was chosen President of the Chicago Astronomical Society, and continued to hold this office until his death, June 28, 1921.

While this record shows the high honor in which he was held by his associates of the Chicago Astronomical Society, it gives necessarily an imperfect idea of the many and varied activities in its behalf which won for him this regard. If the Society needed money, it was his task to secure additional members, much time being required in many cases to convince an indifferent "prospect" that civic duty or pride, or any other motive to which successful appeal could be made required him to part with a hundred dollars for membership in a Society which was likely never to pay a dividend. The year following the great fire of 1871 and the panic of 1873 were critical years in the history of the city, as well as of this Society. There was great depression in commercial and industrial affairs, and men were loath to part with their money unless pecuniary returns seemed certain and immediate.

It was in the midst of this depression that Mr. Colbert, as the result of innumerable personal appeals, raised several thousand dollars for necessary repairs to the Observatory.

About this time the financial affairs of the Chicago University became seriously involved, and the University was no longer able to pay the salary of Professor Safford, Director of the Observatory and Professor of Astronomy in the University. Professor Safford, with the consent of this Society and the University, accepted a position offered him by the U. S. Government, and again Mr. Colbert was called upon to act as Director of the Observatory without pay.

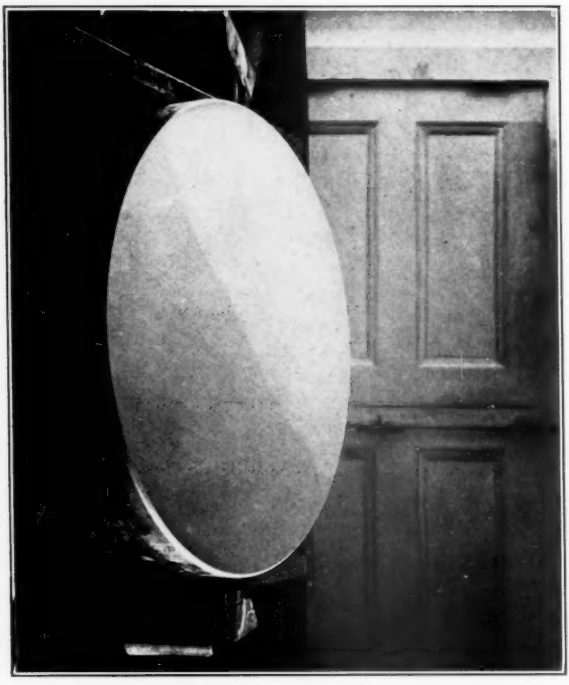
He was appointed Professor of Astronomy in the Chicago University under the Presidency of Dr. Burroughs, and for several years he performed the duties of this position acceptably, and without remuneration. If it seemed desirable to stimulate interest in astronomy by means of public lectures, Professor Colbert was expected to deliver the lectures, or to induce some astronomer of note to do so. And

PLATE VIII.

PROFESSOR ELIAS COLBERT
1829-1921

This plate is taken from a portrait of Professor Colbert painted by Mr. A. F. Brooks of Chicago. The portrait is a gift of the Chicago Astronomical Society to the Dearborn Observatory, where it was recently hung.

PLATE IX.



THE 24-INCH MIRROR AT HARVARD COLLEGE OBSERVATORY
SILVERED AND ONE HALF BURNISHED.

so for half a century Elias Colbert gave his life to the Chicago Astronomical Society.

He was for several years President of the Chicago Press Club, and also of the Bohemian Club. He was active in several British-American Associations. He wrote many pamphlets and minor works, some scientific, and some purely literary in character. His Eulogy of Shakespeare is a gem. Among the best of his minor publications are:

"The Earth Measured"
"The Curve of Immortality"
"Astronomy Without a Telescope"
"Star Studies"
"What We Know of the Universe."

We shall look upon the face of our honored associate no more; but may the memory of his unselfish devotion to the welfare of the Chicago Astronomical Society, inspire us to renewed efforts in behalf of the Organization which was so great a part of his life.

About ten years after the death of his first wife, and nine years after his arrival in Chicago, he married, in 1866, Miss Sarah Cowper, a woman of English birth, then residing in this city, who bore him four children, three of whom died in early life. Professor Colbert's second wife died in 1894, and of all his children, Mrs. George Herbert Jones, only issue of his first marriage, and Mrs. George H. Mason, second daughter of his second wife, alone survive him. Sharing their sorrow, the members of the Chicago Astronomical Society tender to them their heartfelt sympathy, and direct that this Memorial be spread upon the records of the Society, and a copy thereof sent to each of these surviving daughters of our departed associate and friend.

SILVERING MIRRORS.

By EDWARD S. KING.

The method described below is a modification of Lundin's process as developed in experiments made by my son, Everett, who died in 1917. These experiments were made by him when a lad of sixteen years during the summer of 1912. He found that the original formula contained an excess of formaldehyde, so that if the silver nitrate was doubled, a much thicker coat could be obtained. As he remarked, a thick coat of silver stands burnishing better and lasts longer. The chief point he discovered was in regard to the temperature. He found from his experiments, which were carefully recorded with all particulars, that the absolute temperature, within reasonable limits, did not make much difference; but if the mirror was about 10° to 20° Fahr. warmer than the silvering solution, a thicker coat resulted and the

process was more reliable. Some have thought that the stannous chloride used in the Lundin process acts on the surface of the mirror. If it is washed off thoroughly enough to prevent chloride stains on the silver deposit, it seems that no other effect can be possible.

The burnishing of the mirror is of utmost importance. He found by experiment that the average reflectivity of four unburnished mirrors tested was photographically about 58 per cent, against an average of 78 per cent when burnished. The mean of 13 tests gave a reflectivity of 83 per cent after burnishing. The best coat obtained reflected 90 per cent of the photographic light. I enclose a print showing our 24-inch mirror after he had burnished one half of it. The directions, which follow, were prepared by him and are now in use in this observatory. For silvering a 24-inch mirror it requires about two litres of solution or 20 times the formula.

DIRECTIONS FOR SILVERING MIRRORS.

First a saturated solution of stannous chloride is made up, and diluted for use with an equal volume of water. Several wads of clean absorbent cotton are laid out on a clean sheet of paper. The surface of the mirror is carefully rubbed with one of the wads dipped in nitric acid. This removes the old coat of silver, with all the dirt which may be adhering.

After thoroughly washing off the nitric acid, a fresh wad of cotton wet with the stannous chloride solution is rubbed over every part of the surface of the mirror. Water is then poured over the mirror, and the surface is rubbed, first with the same wad, and then with a fresh one. Great care should be taken to remove all traces of the stannous chloride, as, if any is left on, it makes the coat granular. One should be careful not to touch the surface with the fingers, as any trace of grease is fatal.

The mirror, if a small one, may then be placed in a tray just a little larger than itself, and covered with water, at temperature from 65° to 70° F. If a large mirror, a band of waxed paper, tied tightly around the edge, makes a dam and serves the same purpose.

Two solutions are required as follows:

A.	Water	100 cc.
	Silver Nitrate	4.3 g.
	Add strong ammonia just sufficient to redissolve the precipitate first formed.	
B.	Water	20 cc.
	Formaldehyde (Merck)	4 cc.

The temperature of these solutions should be about 45° and 50° F.

The wash water is then poured off the mirror, the solutions quickly mixed and poured over the mirror. Silver will begin to be formed on the surface of the glass almost at once, the solution turning to a red brown color. In about half a minute, the solution begins to turn muddy, with a granular black precipitate. The mirror should be

left in it until this precipitate begins to stick to its surface. This usually requires from three to five minutes. The mirror is then washed with wet cotton and flowing water, and set on edge to dry.

It is important to get as thick a coat as possible, for such a coat stands burnishing better and lasts longer. The thickness can be roughly estimated by observing the amount of light transmitted by it. An electric light filament can barely be seen through a thick coat.

The burnishing is done with a pad of chamois skin, into which some very fine rouge is worked. The best rouge is that washed out from the cloths used after the final polishing in the making of a large lens. The rouge is only sufficient to color the pad. The surface of the pad must be kept perfectly free from dust, or the delicate surface of the silver will be scratched.

(Signed) EVERETT T. KING.

Harvard College Observatory.

THE THIRTY-EIGHT STARS HAVING LARGEST KNOWN PARALLAXES.

By CARL L. STEARNS.

The nearer fixed stars are of special interest on account of the possibility of the close approach of one or more of these bodies to the earth at some distant time, an occurrence which plays an important part in some theories of the evolution of the solar system. The following list, selected by Dr. Schlesinger from a general catalog of parallaxes in preparation, comprises all the stars whose parallaxes have been found to exceed 0″.15, or, in other words, stars which are known to be within twenty-two light years of the earth. This is the distance to which a star would recede in about 300,000 years if it should depart from the immediate vicinity of the earth and travel at a relative speed equal to that of the sun in space, about twenty kilometers per second. It should be pointed out, however, that it is impossible to make a list of all the stars which are within a given distance of the earth, for in addition to possible dark stars, there are doubtless many of the fainter visible stars which are receding from or approaching the earth very nearly in the line of sight and have therefore not attracted the attention of parallax observers by reason of their large proper motions, and our list is consequently incomplete.

The first eight columns of the following table summarize fairly completely our knowledge of the thirty-eight stars which are now within the arbitrarily selected limit mentioned above, containing respectively the designation of the star, its mean right ascension and declination for 1900, visual magnitude, spectral type, total annual proper motion, radial velocity in kilometers per second, if known, and present absolute parallax. The ninth column gives the computed

THIRTY-EIGHT STARS HAVING LARGEST KNOWN PARALLAXES.

	α 1900 h m	δ 1900 ° ′	Visual Magn.	Spectrum	Proper Motion ″	Radial Velocity km.	Present Parallax ″	Maximum Parallax ″	Minimum Distance Light Yrs.	Time of Minimum Distance years	Magnitude at Min. Dist.
*Groombr. 34	0 12.7	+43 27	8.1	Ma	2.89	+ 3	.28	.28	11.6	— 4000	8.1
*η Cassiop.	43.0	+57 17	3.6	F8	1.24	+10	.18	.19	17.1	— 47000	3.5
	43.9	+ 4 55	12.3	F0	3.01		.24				
*κ Tucanae	1 12.4	—69 24	5.0	F8	.39	+12	.16	.23	14.2	—264000	4.2
τ Ceti	39.4	—16 28	3.6	K0	1.92	—16	.32	.37	8.8	+ 46000	3.3
82 Eridani	3 15.9	—43 27	4.3	G5	3.16	+87	.16	.22	14.8	— 33000	3.6
ε Eridani	28.2	— 9 48	3.8	K0	.97	+16	.31	.46	7.1	—106000	3.0
*40² Eridani	4 10.7	— 7 49	4.5	G5	4.08	—42	.21	.23	14.2	+ 19000	4.3
Cordoba Z. 243	5 7.7	—44 59	9.2	K2	8.75	+242	.32	.68	4.8	— 10000	7.6
Weisse 592	26.4	— 3 42	8.8	K2	2.22		.17				
*α Can. Maj. (Sirius)	6 40.7	—16 35	—1.6	A0	1.32	— 8	.37	.41	8.0	+ 65000	—1.8
*α Can. Min. (Procyon)	7 34.1	+ 5 29	0.5	F5	1.24	— 4	.31	.32	10.2	+ 34000	0.5
Fedorenko 1457-8	9 7.6	+53 7	7.9	Ma	1.68	+10	.16	.16	20.4	— 24000	7.9
Groombr. 1618	10 5.3	+49 58	6.8	K5p	1.45	—30	.18	.23	14.2	+ 69000	6.3
Weisse 234	14.2	+20 22	9.0		.49		.19				
Lalande 21185	57.9	+36 38	7.6	Mb	4.78	—87	.41	.76	4.3	+ 20000	6.2
Lalande 21258	11 0.5	+44 2	8.5	K5	4.52	+65	.19	.22	14.8	— 20000	8.2
	12.0	—57 2	12		2.69		.34				
Lalande 25372	13 40.7	+15 26	8.5	K5	2.30		.19				
*α Centauri	14 32.8	—60 25	0.2	G	3.68	+22	.76	1.03	3.2	— 28000	—0.5
*ξ Bootis	46.8	+19 31	4.6	K5p	.17	+ 4	.17	.22	14.8	—598000	4.0
*Lalande 27173	51.6	—20 58	5.8	Kp	1.96	+20	.18	.19	17.1	— 36000	5.6
Weisse 1259	16 41.4	+33 41	8.4		.37		.18				
*Lacaille 7194	17 11.5	—46 32	5 7	K	.97		.19				
*β 416	12.1	—34 53	5.9	K5	1.19	— 4	.17	.17	19.2	+ 21000	5.7
Argel.-Ö. 17415-6	37.0	+68 26	9.1	K	1.33		.22				
Mü, 15040 (Barnard's star)	52.9	+ 4 25	9.7	Mb	10.30	—80	.53	.70	4.7	+ 10000	9.1
*70p Ophiuchi	18 0.4	+ 2 31	4.3	K	1.13		.19				
*Σ 2398	41.7	+59 29	8.8	K	2.31		.29				
σ Draconis	19 32.5	+69 29	4 8	G5	1.84	+26	.20	.23	14.2	— 49000	4.5
α Aquilae (Altair)	45.9	+ 8 36	1.2	A5	.66	—33	.21	.51	6.4	+117000	—0.7
*61 Cygni	21 2.4	+38 15	5.6	K5	5.20	—64	.30	.38	8.6	+ 19000	5.1
Lacaille 8760	11.4	—39 15	6.6	G	3.53	+13	.25	.26	12.6	— 11000	6.6
ε Indi	55.7	—57 12	4.8	K5	4.70	—39	.28	.31	10.5	+ 17000	4.6
*Krüger 60	22 24.4	+57 12	9.2		.87		.26				
Lacaille 9352	59.4	—36 26	7.1	K	6.90	+12	.29	.29	11.2	— 3000	7.1
Lalande 46650	23 44.0	+ 1 52	8.7	Ma	1.39		.17				
C. G. A. 32416	59.5	—37 51	8.2	G	6.05	+26	.22	.22	14.8	— 7000	8.2

* Double.

parallaxes of these stars, with the exception of twelve whose radial velocities have not yet been determined, at the time when they were or will be nearest the earth, and the tenth column gives the corresponding distance in light years. The eleventh column gives the time of closest approach in years, the plus signs referring to the future and the minus signs to the past. The last column gives the visual magnitude at the time of minimum distance.

Yale University Observatory,
May 2, 1921.

THE AMERICAN SECTION OF THE INTERNATIONAL ASTRONOMICAL UNION.

By JOEL STEBBINS.

In view of the coming meeting of the International Astronomical Union which opens in Rome on May 2, 1922, the readers of POPULAR ASTRONOMY will be interested in the organization and plans for American participation in that conference.

At the international conferences in Brussels in 1919 there were formed the new international scientific organizations to take the place of bodies which existed prior to the war. The new parent organization is the International Research Council, under the rules of which were founded separate unions of different sciences, among these being the International Astronomical Union. For each of the unions it was arranged that there would be a national committee in each country which would be the official connection between the union and the national scientific societies, and which would arrange for that country's participation in the work of the union. In the United States these committees are formed by the National Research Council, and in particular astronomy is represented by a committee of the Division of Physical Sciences. The following is the official organization which was adopted by the Research Council in 1920.

ORGANIZATION OF THE AMERICAN SECTION OF THE INTERNATIONAL ASTRONOMICAL UNION.

1. The Executive Committee of the American Section shall consist of the three astronomical members of the Division of Physical Sciences of the National Research Council and (ex officio) of the President and the Secretary of the American Astronomical Society. If the President or the Secretary is a member of the Division of Physical Sciences, the Council of the Society shall appoint a member of the Executive Committee in replacement, so that the Committee shall always consist of five members.

2. The duties of the Executive Committee shall be: to act as the representatives of the United States in the International Astronomical Union in the interim between its triennial meetings; to organize the

American Section and to arrange for a meeting of the American Section shortly preceding each triennial meeting of the Union; to select delegates to the meetings of the Union; and in general to deal with all international astronomical questions involving the participation of the United States. The Chairman of the Executive Committee of the American Section shall (ex-officio) be a member of the Division of Foreign Relations of the National Research Council.

3. Not less than six months before the date of each triennial meeting of the International Astronomical Union the Executive Committee shall invite all American astronomers who are members of the technical committees of the Union, and such other persons as may seem desirable, to submit suggestions for the promotion of the work of the Union. Not less than four months prior to the triennial meeting the Executive Committee shall formulate and make known general plans for a meeting of the American Section of the Union, to be held in Washington not more than two months, and preferably not more than one month, before the date of the triennial meeting of the Union, and, as far as practicable, shall select the astronomical members of the Section. The Executive Committee shall at the same time present to the Division of Physical Sciences of the National Research Council a statement of these plans as a basis for the request that the physicists, mathematicians, and geophysicists who are members of the Division will advise in the selection of delegates to represent their subjects at the coming meetings of the Section and of the Union.

4. The Executive Committee shall select delegates to the meetings of the International Astronomical Union at such times as, in their judgment, seem wise and desirable. Additional delegates to the triennial meetings of the Union may be selected on the initiative of the Section, assembled in Washington, by a majority vote of all members of the Section present.

5. The American Section, excepting its Executive Committee, shall automatically go out of existence at the close of the corresponding triennial meeting of the Union.

The American Section is composed of all astronomers and other scientific men who are members of the technical committees appointed by the Executive Committee. It will be noted that although the Executive Committee is a permanent body, it has a changing membership, especially as there is a new astronomical representative each year on the Division of Physical Sciences. The present personnel of the Executive Committee is W. W. Campbell, *Chairman;* W. S. Eichelberger, H. N. Russell, Frank Schlesinger, and Joel Stebbins, *Secretary.*

The next meeting of the International Astronomical Union will be held in Rome, beginning May 2, 1922. The meeting of 1919 at Brussels was devoted largely to matters of organization and statutes

of convention, but it is expected that this time the discussions will be principally on scientific matters, particularly on the reports of some thirty committees which were appointed at Brussels, and through which the work of the Union will largely be carried on.

In preparation for the meeting at Rome, the Executive Committee of the American Section met recently at Swarthmore and appointed committees of American astronomers to discuss as far as desirable the same fields as the corresponding international committees. There are of course one or more American members on each of the committees of the Union, but it is felt that the American contribution to the work of the international organization will be more intelligent if the delegates from this country are sufficiently well posted on American opinion in the various projects which require international co-operation. Each international committee will report to the general meeting of the Union, as it was decided not to subdivide the main organization into different sections. Three years ago when plans were being prepared for the organization of the Union, there were appointed a number of American committees which made extremely valuable reports on various phases of international astronomical science, and these reports have since been printed in the Bulletin of the National Research Council. It is now proposed that the new American committees supplement the previous reports in so far as that appears desirable, and also committees on fields previously unrepresented will make reports.

At a meeting of the American Section which will be called probably early in April just before the sailing of the delegates, the various committee reports will be acted upon by the Section, which will in this way give instructions to the delegates on the scientific matters. There will also be other matters to arrange at the meeting where it is expected to have a number of representatives of allied sciences present as well as astronomers.

The personnel of the delegation has not yet been determined, but any American member of one of the committees of the Union or of the Section will be eligible to appointment as a delegate. Following is the membership of the committees of the Section.

1. *Committee on Relativity.*—Ludwik Silberstein, *Chairman;* Edward Kasner, A. A. Michelson, D. C. Miller.
2. *Committee on the Re-publication of Early Astronomical Works.*—Henry Crew, *Chairman;* F. E. Brasch, W. C. Rufus.
3. *Committee on Notation, Units, and Economy of Publication.*—W. J. Humphreys, *Chairman;* R. G. Aitken, Benjamin Boss.
4. *Committee on Ephemerides.*—W. S. Eichelberger, *Chairman;* E. W. Brown.
5. *Committee on Abstracts and Bibliography.*—H. D. Curtis, *Chairman;* F. E. Fowle, G. S. Fulcher.
6. *Committee on Astronomical Telegrams.*—Harlow Shapley, *Chairman;* S. I. Bailey.
7. *Committee on Dynamical Astronomy and Astronomical Tables.*— E. W. Brown, *Chairman;* A. O. Leuschner, F. R. Moulton.
8. *Committee on Meridian Astronomy (including Refraction).*—Benjamin Boss *Chairman;* F. B. Littell, J. G. Porter, R. H. Tucker.

9. *Committee on Theoretical and Applied Optics and the Study of Instruments.*—A. C. Lunn, *Chairman;* F. B. Littell, F. E. Ross.

10. *Committee on Solar Radiation.*—C. G. Abbot, *Chairman;* F. E. Fowle, H. H. Kimball.

11. *Committee on the Spectro-Helio-Enregistreur.*—No appointment.

12. *Committee on the Solar Atmosphere.*—George E. Hale, *Chairman;* O. J. Lee, C. E. St. John.

13. *Committee on Astronomical Expeditions, Eclipses, etc.*—W. W. Campbell, *Chairman;* H. D. Curtis, S. A. Mitchell.

14. *Committee on the Determination of Wave-Lengths and Tables of the Solar Spectrum.*—C. E. St. John, *Chairman;* H. D. Babcock, Keivin Burns, W. F. Meggers.

15. *Committee on Solar Rotation.*—C. E. St. John, *Chairman;* W. S. Adams, Philip Fox.

16. *Committee on Physical Observations of the Planets.*—E. E. Barnard, *Chairman;* C. O. Lampland, E. C. Slipher.

17. *Committee on Lunar Nomenclature.*—W. H. Pickering, *Chairman.*

18. *Committee on the Determination of Terrestrial Longitude by Wireless Telegraphy.*—*Captain* W. D. MacDougall, *Chairman;* W. W. Campbell, J. J. Carty.

19. *Committee on the Variation of Latitude.*—F. E. Ross, *Chairman;* W. D. Lambert, F. B. Littell, Frank Schlesinger.

20. *Committee on Asteroids.*—E. W. Brown, *Chairman;* A. O. Leuschner, Joel H. Metcalf, G. H. Peters, H. C. Wilson.

21. *Committee on Comets.*—A. O. Leuschner, *Chairman;* E. E. Barnard, V. M. Slipher.

22. *Committee on Meteors.*—S. A. Mitchell, *Chairman;* G. P. Merrill, C. P. Olivier.

23. *Committee on the Carte du Ciel.*—Frank Schlesinger, *Chairman.*

24. *Committee on Stellar Parallaxes.*—Frank Schlesinger, *Chairman;* W. S. Adams, H. D. Curtis, Philip Fox, J. A. Miller, S. A. Mitchell, Harlow Shapley, Frederick Slocum, George Van Biesbroeck, Adrian van Maanen.

25. *Committee on Stellar Photometry.*—F. H. Seares, *Chairman;* J. A. Parkhurst, Harlow Shapley, Joel Stebbins.

26. *Committee on Double Stars.*—R. G. Aitken, *Chairman;* G. C. Comstock, Philip Fox, W. J. Hussey, H. N. Russell, George Van Biesbroeck.

27. *Committee on Variable Stars.*—S. I. Bailey, *Chairman;* Leon Campbell, R. S. Dugan, F. C. Jordan, H. N. Russell, Harlow Shapley, Joel Stebbins, R. H. Baker.

28. *Committee on the Nebulae.*—V. M. Slipher, *Chairman;* E. E. Barnard, E. P. Hubble, C. O. Lampland, W. H. Wright.

29. *Committee on the Spectral Classification of Stars.*—W. S. Adams, *Chairman;* Annie J. Cannon, R. H. Curtiss, P. W. Merrill, H. N. Russell, Harlow Shapley, W. H. Wright.

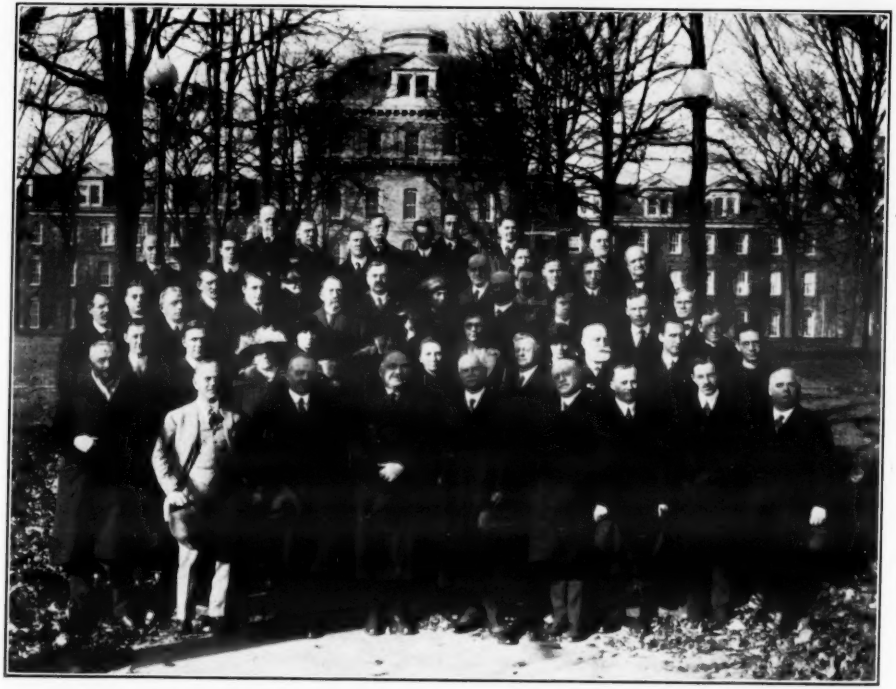
30. *Committee on Stellar Radial Velocities.*—W. W. Campbell, *Chairman;* W. S. Adams, Sebastian Albrecht.

31. *Committee on Time.*—Captain W. D. MacDougall, *Chairman.*

32. *Committee on the Reform of the Calendar.*—R. T. Crawford, *Chairman;* W. W. Campbell, Harold Jacoby.

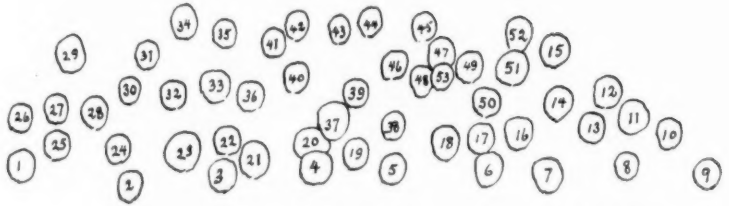
University of Illinois Observatory,
January 20, 1922.

PLATE X.



SWARTHMORE MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY

KEY TO PLATE X.



1. Brown
2. Boss
3. H. D. Curtis
4. Schlesinger
5. St. John
6. Miller
7. Albrecht
8. Stetson
9. H. C. Wilson
10. Phillips
11. Brock
12. Hedrick
13. J. A. Snyder
14. J. Q. Stewart
15. Quimby
16. M. B. Snyder
17. Miss Moore
18. Peters
19. Miss Young
20. Mrs. Miller
21. Miss Cannon
22. Miss France
23. Miss Furness
24. S. A. Mitchell
25. Slocum
26. Boothroyd
27. Mátos
28. Russell
29. Dugan
30. Alter
31. Sitterly
32. Menzel
33. Mrs. Marshall
34. Hall
35. Eichelberger
36. Howe
37. Miss Palmer
38. Miss Powell
39. Miss Barney
40. Derr
41. Duncan
42. Pawling
43. Morgan
44. Shelley
45. Barton
46. Lambert
47. Burns
48. Stebbins
49. Stearns
50. Shapley
51. Rorer
52. Durant
53. Pitman

TWENTY-SEVENTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

The twenty-seventh meeting of the Society was held at the Sproul Observatory, Swarthmore College, Swarthmore, Pennsylvania, from December 29 to 31, 1921, on the invitation of the director, Professor John A. Miller. From the hospitality which the Society had enjoyed at Swarthmore in 1916, it was well known in advance that the meeting would be a success, and the good attendance demonstrated that twice each year is none too often for the Society to hold its gatherings.

The members were housed in Parrish Hall, the main building and dormitory of the college, and meals were served in the large dining room. Because of the winter season there were no excursions, so the meeting took on the nature of a large house party for two days and a half, however with the usual strenuous program of scientific papers, which no matter how many or how few always bring up enough discussion so that the last session is crowded. Time was taken out for the annual photograph, and as it seems that various members of the Society claim to resemble its president in appearance, the opportunity was taken to line up all of these pseudo-presidents alongside the original for a permanent record.

On the first evening the Society was cordially received by President and Mrs. Aydelotte at their home on the campus, a delightful occasion for the guests.

A special program was arranged for the second evening, when the Society was privileged to listen to an address by Dr. William Romaine Newbold, professor of philosophy in the University of Pennsylvania, on the subject "Evidence contained in the Voynich Manuscript that Roger Bacon possessed a Telescope." It was rare good fortune for the members to hear from such an authority a discussion of the famous cipher and other evidence in favor of the view that Bacon had at least a crude telescope some three centuries before Galileo's time. So new and unfamiliar was this line of discussion on a partly astronomical topic, that very few of us were prepared to form a judgment in the matter, but the Society expressed its sincere appreciation to Professor Newbold for his interesting and inspiring address.

The remainder of the evening was taken up with a series of illustrated talks on the human phases of life and the scenic attractions at some of the large American observatories, the directors of which had kindly forwarded numerous beautiful lantern slides, which were explained by members of the staffs, or by recent visitors at these institutions. There was some doubt as to the proper order of precedence of the different exhibits, but it was finally decided to call on them according to the longitude of the observatories, with some degree of latitude left to the chairman.

The meeting closed at Saturday noon, in time for most of the visitors to return home by New Year's Day. Before adjournment the

Society expressed its formal thanks to the authorities of Swarthmore College, to President and Mrs. Aydelotte, and to Professor and Mrs. Miller and the staff of the Sproul Observatory.

The following persons were elected to membership, making a total of three hundred and seventy members in the Society:

S. L. Boothroyd, Cornell University, Ithaca, N. Y.
M. Alberta Hawes, Vassar College Observatory, Poughkeepsie, N. Y.
W. D. Lambert, U. S. Coast and Geodetic Survey, Washington, D. C.
Knut Lundmark, Lick Observatory, Mount Hamilton, Calif.
D. H. Menzel, Graduate College, Princeton, N. J.
Charlotte E. Moore, 13 Vandeventer Avenue, Princeton, N. J.
F. H. Safford, University of Pennsylvania, Philadelphia, Pa.
B. W. Sitterly, Graduate College, Princeton, N. J.
J. A. Snyder, 113 Essex Avenue, Narberth, Pa.
J. Q. Stewart, 14 Prospect Avenue, Princeton, N. J.

Members in attendance at the Swarthmore meeting were:

Sebastian Albrecht	H. A. Howe	H. B. Rumrill
Dinsmore Alter	W. D. Lambert	H. N. Russell
Ida Barney	J. D. Maddrill	F. H. Safford
S. G. Barton	W. A. Mâtos	C. E. St. John
S. L. Boothroyd	D. H. Menzel	Frank Schlesinger
Benjamin Boss	J. A. Miller	Harlow Shapley
E. W. Brown	S. A. Mitchell	B. W. Sitterly
Keivin Burns	W. M. Mitchell	Frederick Slocum
Annie J. Cannon	Charlotte E. Moore	J. A. Snyder
H. D. Curtis	H. R. Morgan	M. B. Snyder
Louis Derr	Margaretta Palmer	C. L. Stearns
R. S. Dugan	Jesse Pawling	Joel Stebbins
J. C. Duncan	G. H. Peters	H. T. Stetson
W. S. Eichelberger	E. C. Phillips	J. Q. Stewart
Jennie V. France	J. H. Pitman	John Tatlock
Caroline E. Furness	Margaret E. Powell	H. C. Wilson
Asaph Hall	A. W. Quimby	Anne S. Young
H. B. Hedrick	J. T. Rorer	

The Council announced that the next meeting of the Society would be held at the Yerkes Observatory during the week immediately following Labor Day in September, 1922. This will be in the nature of a twenty-fifth anniversary of the dedication of the Yerkes Observatory, and of the foundation of the Society, which grew out of the conference in connection with the dedication in the autumn of 1897.

The place for the next winter meeting was not definitely decided upon, but the Council tentatively agreed to hold a meeting of the Society at the Mount Wilson Observatory, immediately following the total solar eclipse of September, 1923, and also accepted the invitation of Miss Furness to meet at Vassar College in December, 1923.

ABSTRACTS OF PAPERS.

SPECTROSCOPIC NOTES ON SOME VARIABLE STARS.

By Walter S. Adams and A. H. Joy.

Spectra of the following variable stars taken with the 100-inch reflector and a one-prism slit spectrograph show interesting peculiarities.

SS CYGNI.

Maximum: Spectrum is continuous with faint dark bands of hydrogen and helium about 20 angstroms wide.

Minimum: Strong bright bands of hydrogen and helium about 20 angstroms wide but not displaced. Possibly a few faint absorption lines.

The spectrum of this star bears considerable resemblance to that of novae.

U SAGITTAE.

Successive spectrograms of this Algol variable show a change of type from B8 at maximum to G0 at minimum. The greater brightness of the B-type component prevents the more advanced type of spectrum from showing until near total eclipse. It is estimated that the G0 star belongs to the giant division.

W CEPHEI.

The hydrogen lines are bright and fairly narrow, Hα being the strongest of the series. A number of other bright lines are present, several of which have not been identified as yet. There are traces of the bands characteristic of type M and the spectrum is very similar to that of the well-known star Boss 5650.

o CETI

The spectrum of this star near the present minimum shows a recurrence of the remarkable characteristics observed last year. The broad diffuse components of the bright hydrogen lines are displaced 2.3 angstroms toward the red, and absorption lines are present at Hγ and Hβ displaced about 2 angstroms toward the violet. The narrow bright lines show the usual difference of —15 km relative to the normal dark lines of the spectrum.

The longitudinal displacement of the diffuse hydrogen and helium lines with reference to the sharp bright lines and the continuous spectrum amounts to about 0".3 in angular measure at the focus of the telescope.

PARTIAL EXPLANATION, BY WAVE-LENGTHS, OF THE K-TERM IN THE B TYPES.

BY SEBASTIAN ALBRECHT.

The K-term, which is a systematic average residual velocity remaining after the radial component of the sun's motion in space has been deducted from the radial velocity of each star, can be interpreted as the effect of either an expanding universe, for the stars employed, or the use of normal wave-lengths which are systematically too low. It was shown that at least part of the K-term must be attributed to the latter cause.

At the Ottawa meeting (*Publications of the Astronomical and Astrophysical Society of America*, **2**, 71, 1911) attention was called

to the unsatisfactory state of our knowledge in regard to the normal wave-lengths upon which the radial velocities of the B-type stars depend. This is especially true for the three silicon lines λ 4552, λ 4567 and λ 4574, for which the best two laboratory determinations differ in the mean by 0.09A, which corresponds to a difference of 6.0 km per second in the radial velocities derived from them. For the oxygen and nitrogen lines new laboratory wave-lengths were recently determined by Clark (*Astrophysical Journal*, **40**, 332, 1914), and the effect of the changes in wave-length upon the radial velocities and therefore also upon the K-term can be approximated.

The table, which is self-explanatory, contains the oxygen and nitrogen lines which were included in the reductions for radial velocity. The mean change in the radial velocities obtained from these lines is —4.2 km, and had only these lines been employed then the entire K-term for the B types would be accounted for. However, as the oxygen and nitrogen lines constitute only a small fraction of all the lines used, their net effect upon the K-term amounts to less than 1 km. In proportion to the relative frequency with which these lines are represented in the measures of Campbell's stars, the effect is as great as is to be anticipated. Additional portions of the K-term may, in a similar way, be due to other groups of lines. Further laboratory study is especially desired for the lines of silicon and helium.

λ Clark	λ Normal (Frost & Adams)	λ Clark —λ Normal A	Change in Radial Velocity km	Element
4317.327	.272	+0.055	—3.8	O
19.814	.762	+0.052	—3.6	O
45.738	.677	+0.061	—4.2	O
48.246	.134	+0.112	—7.7	N
49.602	.541	+0.061	—4.2	O
51.443	.495	—0.052	+3.6	O
67.074	.012	+0.062	—4.3	O
4415.057	.076	—0.019	+1.3	O
17.143	.121	+0.022	—1.5	O
4447.205	.163	+0.042	—2.8	NO
4591.158	.066	+0.092	—6.0	O
96.365	.291	+0.074	—4.8	O
4621.582	.548	+0.034	—2.2	N
30.729	.703	+0.026	—1.7	N
39.043	.937	+0.106	—6.9	O
42.006	.886	+0.120	—7.8	O
49.327	.250	+0.077	—5.0	O
51.032	.925	+0.107	—6.9	NO
61.829	.728	+0.101	—6.5	O
4676.426	.291	+0.135	—8.7	O
Means (20 lines)		+0.063	—4.2	

POSSIBLE PERIODICITY IN MEAN SUN-SPOTTEDNESS.

By Dinsmore Alter.

We can define mean sun-spottedness as the average count of sun-spots between any two consecutive maxima or minima. These mean

counts can be plotted as ordinates against the times as abscissae. The irregular curve obtained in this way represents the variation in mean sun-spottedness during the last 150 years. This curve can be very closely represented by the following simple formula in which 46 is the grand mean sun-spottedness:

$$I = 46 - 11 \sin 2\pi \frac{4(T-1799)}{30\times 11.125} - 9 \sin 2\pi \frac{5(T-1799)}{30\times 11.125} - 7 \sin 2\pi \frac{7(T-1799)}{30\times 11.125}$$

The danger of claiming anything real in the representation of data by a Fourier series is of course recognized, but the simplicity of this formula, due to the small number of terms and each term using the same basic year, is sufficient to warrant watching its representation during coming years.

This paper is part of an investigation, not yet finished, the first paper of which was read at Chicago, December 1920.

DEMONSTRATION APPARATUS FOR DESCRIPTIVE ASTRONOMY CLASS.

By Dinsmore Alter.

In this paper were described demonstration apparati for the following difficult points in a descriptive astronomy course:

(a) Three coördinate systems.
(b) The effects of precession on the various coördinates.
(c) Aberration of light.
(d) The elements of an orbit.

In addition to this, a switchboard especially designed for observatory use was shown.

A complete description of these devices with illustrations of each will appear in an early number of Popular Astronomy.

ON ABSOLUTE MAGNITUDES.

By Benjamin Boss.

The absolute magnitudes treated were formed from the parallaxes corrected by the tabulated quantities in *Astronomical Journal* No. 771. The frequency curves for different divisions of type indicate a maximum for the giant stars of M = +0.75, the bulk of the giant stars lying between M = —1.5 and +3.0. The striking lack of giant stars among the later A and among the F type stars is evident. When maxima of dwarf distribution are plotted a very smooth curve can be fitted to them.

The progression in the size of mean proper-motion with progression in absolute magnitude is very regular. While the same progression in radial velocity and space velocity is not as smooth, on account of the less material available, it is manifest. The mean space velocity

is approximately double that of the mean radial velocity, the condition fulfilled by random motion.

The distribution curve for the absolute magnitudes of all types combined is approximately fitted by a Gaussian distribution, on the assumption of a probable error of ± 1.9 magnitude. There are however marked deviations from this curve.

A division of the mean absolute magnitudes according to galactic latitude shows no appreciable peculiarity.

THE MOON'S MOTION—A POSTSCRIPT.

By Ernest W. Brown.

The long outstanding question of the so-called secular acceleration of the moon's motion, or retardation of the earth's rate of rotation, seems at last to have been settled. On the observational side, the work of Fotheringham at Oxford on the ancient eclipses and other recorded lunar phenomena shows that the cumulative observational evidence for the reality of the phenomena is sufficiently good to be relied upon. Within the last two years, G. I. Taylor and H. Jeffries have obtained figures for the frictional effect of the tides in shallow seas which give a retardation of the earth's rate of rotation of the same magnitude as that furnished by the ancient observations. And finally, the present author points out that with Fotheringham's value for the mean motion, the minor fluctuations, which have been increasing during the last twenty years with the Newcomb value (which is substantially that adopted in the new Tables), are reduced to the same order of magnitude as they have had during the last century. The question of the validity of the new value will probably be definitely settled within the next two decades. The other outstanding differences, namely the great empirical term and the minor fluctuations, are periodic in character and have received no accepted explanation.

MEDIAN PARALLAX; A STATISTICAL METHOD.

By Keivin Burns.

For nearly all the stars of magnitude 5.0 and brighter the proper motions and radial velocities with respect to the sun are known. It has been shown that the median parallax for any class of stars in this group may be found by multiplying the quotient of the mean proper motion and the mean radial velocity by the factor 3.02. The present paper demonstrates that median of the proper motions and velocities may be used in the same manner. The question has been raised as to whether the parallax so derived is a mean value or a median value. This question is answered by the demonstration of the following theorem: If a number from one series is divided by a number from another series, pairing at random, the median of the quotients is the quotient of the medians of the two series.

RESUME OF RESULTS BEARING ON THE ABSOLUTE MAGNITUDES OF THE STARS.

By Heber D. Curtis.

The absolute magnitudes of 2375 stars, plotted by spectral type, were shown in a diagram which combined the spectrographic results of Adams, the hypothetical parallaxes of Jackson and Furner, and strictly modern photographic parallaxes. This combination of absolute magnitudes derived by three different methods emphasizes the progression with spectral type pointed out by Russell, as well as the essential agreement of the methods employed.

CHANGES IN THE SPECTROGRAPHIC ELEMENTS OF Y SAGITTARII.

By John C. Duncan.

Y Sagittarii is a well-known variable star of the δ Cephei class. The variability of its brightness was discovered by Sawyer in 1886, and that of its radial velocity by Curtiss in 1904. In 1909 I published a preliminary velocity curve and elliptic elements derived from observations made with the single-prism spectrograph of the Lick Observatory[1] in 1908. Last winter my attention was called by Mr. Joy of the Mount Wilson Observatory to the fact that four observations made there in 1918 gave a velocity some twenty kilometers below that shown by my curve of 1908; and I then undertook a new determination of the curve.

The star was placed by Dr. Adams on the observing list of the 60-inch and 100-inch reflectors, and in the spring and summer of 1921 seventeen one-prism spectrograms were secured. An approximate curve derived from these observations showed unmistakably a velocity of the system several kilometers below that of the Lick plates of 1908. Though this difference seemed too great to be due to instrumental causes, that question was referred to Director Campbell, who, to make sure, had three plates made at salient points of the curve with the three-prism Lick spectrograph. These plates agree well with the Mount Wilson plates, and in the final determination of the elements were given additional weight on account of their high dispersion.

Corrections, both to the elements of 1921 and to those of 1908, were computed by the method of least squares. The results follow:

	1908	1921	Difference
K	19.3 ± 0.8 km/sec.	20.6 ± 0.8 km/sec.	+1.3 ± 1.2 km/sec.
ω	43°.0 ± 13°.8	74°.5 ± 6°.2	+31°.5 ± 15°.1
e	0.21 ± 0.04	+0.42 ± 0.04	+0.21 ± 0.06
T	4.51 ± 0.21 days	5.05 ± 0.08 days	+0.54 ± 0.22 days
γ	+3.6 ± 1.2 km/sec.	−5.9 ± 1.5 km/sec.	−9.6 ± 1.9 km/sec.
$a \sin i$	1,500,000 km.	1,354,000 km.	−146,000 km.
$\frac{m^3 \sin^3 i}{(m+m_1)^2}$	0.004 ⊙	0.003 ⊙	−0.001 ⊙
P	5.773268 days		

[1] *Lick Observatory Bulletin*, **5**, 82, 1909.

The period assumed is the one found from photometric observations by Hellerich.[2] The probable error of a Lick plate of 1908 is ±2.4 km/sec; that of a Mount Wilson plate, ±3.1 km/sec.

Of the changes found, the most important are those in e and γ, which are so large as to seem certainly not due to errors of observation.

ON THE DAILY VARIATION IN CLOCK CORRECTIONS.

By W. S. Eichelberger and H. R. Morgan.

The results presented in this paper were obtained from a discussion of about 6000 observations made with the 9-inch Transit Circle of the U. S. Naval Observatory during the years 1903-1911. The details of the discussion will appear in the *Astronomical Journal.*

It is found, by omitting all daylight observations, by eliminating periodic errors from the right ascensions of the clock stars and daily variations in the instrumental constants, and by keeping the clocks under constant pressure and constant temperature, that the daily variation of the clock corrections at the U. S. Naval Observatory for a period of eight years is a negligible quantity.

A NEW ORBIT OF NEPTUNE'S SATELLITE.

By W. S. Eichelberger and Arthur Newton.

The observations discussed in this paper were made at eighteen different oppositions of Neptune from 1889 to 1908, at eight different observatories, and by thirteen different observers.

As stated at the Middletown meeting in 1921, the mass of Neptune obtained from the visual observations was in close agreement with previous determinations, while that obtained from the photographic observations was about 1/40 smaller.

No remarkable divergence from previously determined elements appeared except that the eccentricity was smaller than generally found.

STELLAR PARALLAXES DETERMINED AT DEARBORN OBSERVATORY.

By Philip Fox.

This paper presented by means of tables in lantern slide form the results of stellar parallaxes of 44 stars in 34 different fields. These parallaxes, which will be published in the *Comptes Rendus,* are the current results on the stars of the published program. One or two

[2]Inaugural Dissertation, Berlin, 1913.

of them perhaps merit individual remark. B. D. —21°607 and B. D. —21°5840 are suggested members of Corlin's Monoceros Stream. Their parallaxes are respectively 0″.017 and 0″.050.

Occasionally in double stars, where we are led to expect identical parallaxes, large discrepancies are found between individual parallaxes of a pair. Such a case is found in B. D. + 59° 183 = Σ 2128. For members of this pair the measurements of Miss Hill gave a difference of 0″.063, with individual probable errors each of ±0″.010. The field was remeasured by Fox, who found a difference in the parallaxes of 0″.044, with individual probable errors ±0″.008 and ±0″.010. Such discrepancies are seen in other lists, but seldom of such magnitude. This particular pair shows no orbital motion, but is a case of common proper motion, this latter fact being borne out very clearly by this series of measures. The difference in parallax may be real; if not, its presence is rather disquieting. The cause of it may be in photographic displacement of nearby images.

(To be continued.)

NOTES ON THE MOON.

By ELIHU THOMPSON.

It sometimes happens, as was the case when the moon was in its first quarter recently (about Nov. 7th) that the full body of the moon is visible. It is common enough at the time of new moon, when there is a thin crescent, that the body of the moon shows up quite clearly as illuminated by the earth light; that is, that the solar light reflected and diffused from the earth reveals the body of the moon, and the tint of the moon is then greenish, or olive green, which would be the natural result of the color of the ocean, of the earth and vegetation on its surface. In the late instance of the full body of the moon being visible, even a little past the first quarter, the cause most probably has been that the earth was presenting toward the moon an unusual brightness. This might be the result of very widely extended cloud areas on the earth, from which clouds, naturally white in color, the solar light was reflected to an unusual degree, but it might also be caused by the existence of great snow covered areas on the side of the earth presented to the moon and illuminated in the full sun. More probably the cause of earth light which would make the body of the moon visible at first quarter or after was due to a combination of these two things; great snow covered areas, say in the north in British America and northern Siberia, combined with cloud areas in other parts of the world, temporarily increasing, as we may

say, the albedo of the earth. I may add that in no other experience of mine, has the body of the moon shown so clearly as on this particular occasion mentioned, when the moon had passed its first quarter. It should be stated that the appearance was observed about one and one-half hours after sunset, when the sky had been darkened and the sky itself was clear and without haze.

Recent statements emanating from Prof. William H. Pickering, observing at Jamaica, have been to the effect that he has convinced himself, from the changes in aspect of the moon's surface during the lunar day, that such surface instead of being dead and lifeless, has really a considerable and rather remarkable vegetable growth, in spite of the evidences of almost complete vacuum surrounding the moon.

The writer, more than forty years ago, carried on an investigation with his colleague, the late Prof. E. J. Houston, on the changes of color of substances by heat, in which it was shown that cooling generally resulted in such color changes as brought the color higher in the spectrum, and that the heating generally carried the color down in the spectrum, some reds becoming even totally black. Quite a list of common compounds, such as oxides, sulphides, salts, etc., of the metals, were experimented with, and the results noted in a paper published in the Journal of the Franklin Institute, a brief abstract of that paper appearing in Watts' Dictionary of Chemistry (Vol. 7, 2nd supplement).

Now, can it not be easily possible that Prof. Pickering's observations are accounted for by the natural changes of color which any mixed surface would undergo by variations of temperature? The surface of the moon would be exposed for fourteen days to the intense cold of space, uncovered by any mitigating blanket of gas. That surface would, in the lunar night, reach an extremely low temperature. In the same way, within a few days after sunrise on the moon, there would be a decided warming-up, the rise of temperature of the lunar surface exposed to the sun reaching the maximum perhaps a little past high noon, or vertical position of the sun with respect to the moon, or a little past the middle of the lunar day. Further on, the cooling process would begin, and some time before total sunset on the moon, the cooling would have reduced the temperature very considerably and be carried to the former minimum during the next lunar night. The heating process during the lunar day would act differently upon different parts of the surface, changing the tint or coloring, the general tendency during the heating being to a darkening, and during the night to a lightening of color. These facts, given their proper value, it seems to me may serve as an explanation of the results obtained by Professor Pickering, at least in a large measure, and relieve us from the necessity for considering that the moon has or is able to accumulate a coating of vegetation such as he assumes.

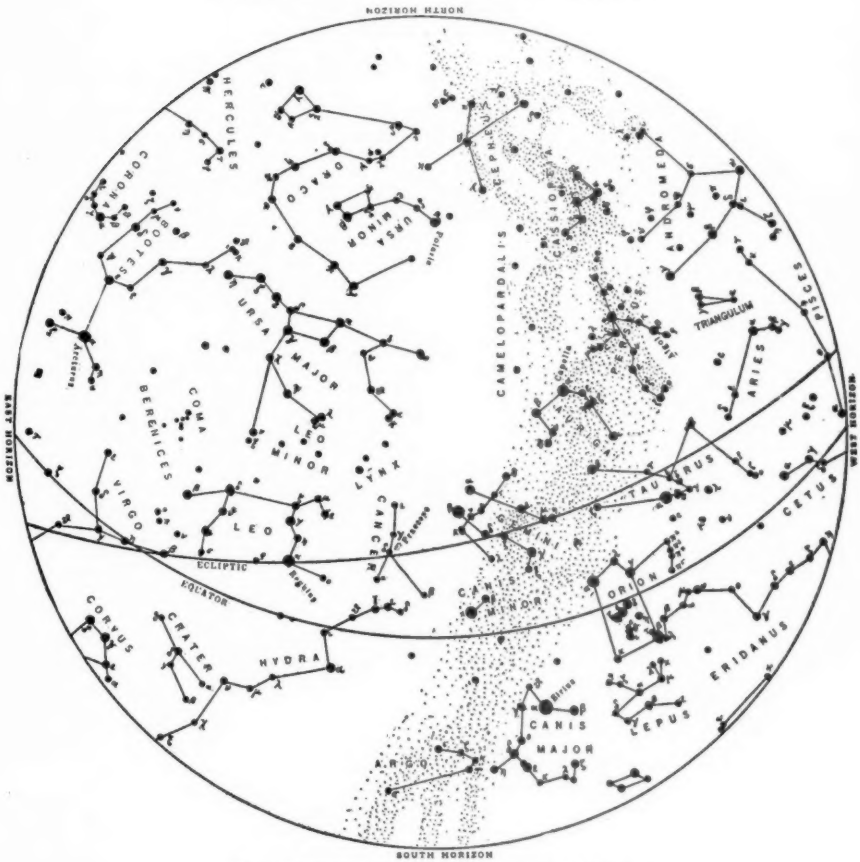
Lynn, Mass., Nov. 16, 1921.

PLANET NOTES FOR MARCH.

(The times given are in Central Standard Time.)

The phases of the *moon* will occur as follows:

	d	h	m
First quarter	March 6	1	21.6 P. M.
Full moon	13	5	14.4 A. M.
Last quarter	20	2	43.0 A. M.
New moon	28	7	03.4 A. M.



THE CONSTELLATIONS AT 9:00 P. M. MARCH 1.

An annular eclipse of the *sun* will occur on the 28th. The central line of eclipse begins in western South America about eight degrees south of the equator, crosses the equator in longitude 38° west and ends near the northern end of the Persian Gulf. The eclipse begins at 4:01 A. M. and ends at 10:09

A. M. At mid-eclipse the dark body of the moon will be surorunded by a ring of sunlight about 1'.2 wide.

The *sun* enters the sign of Aries and spring commences on the 21st at 3:49 A. M.

Mercury will reach greatest western elongation on the 12th at 1:00 P. M. The planet's distance from the sun will be 27° 32'. For a day or two before and after this date it will be possible to see Mercury with the naked eye as it will rise about an hour and a half before the sun. Its declination will be 14° south.

Venus will be the most conspicuous star in the evening sky just after sunset. On the 15th it will set about 34 minutes after the sun. An occultation of Venus by the moon will occur on the morning of the 29th. On the evening of that day the planet and the crescent moon will still be near enough together to produce an interesting sight.

Mars, having passed quadrature in February, will rise before midnight. The planet's distance from the earth will average about 100 million miles. Its apparent diameter will increase from 8" to 10" during the month and its stellar magnitude will change from +0.6 to 0.0.

Jupiter will cross the meridian about 2:09 A. M. on the first and about midnight at the end of the month. An occultation by the moon will occur on the 14th but will be visible as such only in the southern hemisphere. In the northern hemisphere the moon will pass south of the planet. The two bodies will be in conjunction in right ascension at 8:43 P. M. of the date given.

Saturn will be a few degrees west of Jupiter and will reach opposition on the 25th at 11:00 A. M. Both planets will be in good position for observation after 10:00 P. M.

Uranus, having been in conjunction with the sun on the last of February, will not be in position for satisfactory observation.

Neptune will be in good position for observation in the evening as it reached opposition early in February, but a telescope will be required to see it.

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1922	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle from N	EMERSION. Washington M.T.	EMERSION. Angle from N	Duration
			h m	°	h m	°	h m
Mar. 5	63 Tauri	5.7	9 16	77	10 23	279	1 07
7	124 H^1 Orionis	5.7	8 16	74	9 30	299	1 14
7	292 B Orionis	6.5	12 09	46	12 45	331	0 36
8	λ Geminorum	3.6	10 54	89	12 00	298	1 07
9	30 B. Cancri	6.1	6 46	110	8 03	274	1 17
10	209 B. Cancri	6.5	6 08	99	7 17	288	1 09
12	75 Leonis	5.4	11 04	109	12 19	304	1 15
12	76 Leonis	6.0	12 17	138	13 27	275	1 10
12	79 Leonis	5.5	15 09	63	15 50	342	0 41

Saturn's Satellites.

Greatest elongations visible in the United States.
[From the *American Ephemeris.*]
CENTRAL STANDARD TIME.

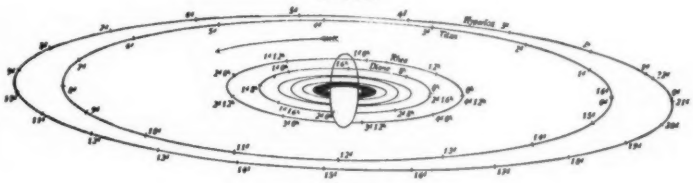
I. Mimas. Period 0d 22h.6.

1921	d	h		d	h		d	h		d	h
Mar.	1	13.3 E	Mar.	9	13.5 W	Mar.	17	13.7 E	Mar.	25	13.9 W
	2	11.9 E		10	12.2 W		18	12.3 E		26	12.5 W
	3	10.5 E		11	10.7 W		19	10.9 E		27	11.2 W
	4	9.1 E		12	9.3 W		20	9.5 E		28	9.8 W
	5	19.0 W		13	19.2 E		21	19.5 W		29	8.4 W
	6	17.6 W		14	17.8 E		22	18.1 W		30	18.3 E
	7	16.3 W		15	16.5 E		23	16.7 W		31	16.9 E
	8	14.9 W		16	15.1 E		24	15.3 W			

II. Enceladus. Period 1d 8h.9.

Mar.	1	9.1 E	Mar.	9	14.4 E	Mar.	17	23.6 E	Mar.	26	0.9 E
	2	18.0 E		10	23.2 E		19	4.5 E		27	9.8 E
	4	2.9 E		12	8.1 E		20	13.4 E		28	18.6 E
	5	11.7 E		13	17.0 E		21	22.2 E		30	3.5 E
	6	20.6 E		15	1.9 E		23	7.1 E		31	12.4 E
	8	5.5 E		16	10.7 E		24	16.0 E			

SOUTH



NORTH

Apparent orbits of the seven inner satellites of Saturn, at date of opposition, March 25, 1922, as seen in an inverting telescope, and elongated in the ratio of three to one in the direction of their minor axes.

III. Tethys. Period 1d 21h.3.

Mar.	2	4.2 E	Mar.	9	17.3 E	Mar.	17	6.5 E	Mar.	24	19.6 E
	4	1.4 E		11	14.6 E		19	3.8 E		26	16.9 E
	5	22.7 E		13	11.9 E		21	1.0 E		28	14.2 E
	7	20.0 E		15	9.2 E		22	22.3 E		30	11.5 E

IV. Dione. Period 2d 17h.7.

Mar.	2	5.5 E	Mar.	10	10.5 E	Mar.	18	15.4 E	Mar.	26	20.4 E
	4	23.2 E		13	4.1 E		21	9.1 E		29	14.0 E
	7	16.8 E		15	21.8 E		24	2.7 E			

V. Rhea. Period 4d 12h.5.

Mar.	3	8.2 E	Mar.	12	8.8 E	Mar.	21	9.5 E	Mar.	30	10.1 E
	7	20.5 E		16	21.2 E		25	21.8 E			

VI. Titan. Period 15d 23h.3.

Mar.	6	6.4 E	Mar.	14	3.0 W	Mar.	22	4.0 E	Mar.	30	0.4 W

VII. Hyperion. Period 21d 7h.6.

Mar.	6	23.5 W	Mar.	18	22.1 E	Mar.	28	1.8 W			

VIII. Iapetus. Period 79d 22h.1.

Mar.	2	20.6 W	Mar.	23	3.5 E						

IX. Phoebe. Period 523d 15h.6.

		α Ph.—α Sat.	δ Ph.—δ Sat.			α Ph.—α Sat.	δ Ph.—δ Sat.
		m s	′ ″			m s	′ ″
Mar.	2	−2 25.2	+18 17	Mar.	18	−2 24.1	+18 00
	4	2 25.3	18 16		20	2 23.7	17 56
	6	2 25.3	18 15		22	2 23.3	17 52
	8	2 25.2	18 14		24	2 22.8	17 47
	10	2 25.1	18 12		26	2 22.2	17 41
	12	2 24.9	18 10		28	2 21.6	17 35
	14	2 24.7	18 07		30	2 21.0	17 29
	16	−2 24.4	+18 04	Apr.	1	−2 20.3	+17 22

NOTE:—E, Eastern Elongation; I, Inferior Conjunction (south of planet); W, Western Elongation; S, Superior Conjunction (north of planet).

Phenomena of Jupiter's Satellites.

VISIBLE AT WASHINGTON.

[From the *American Ephemeris*.]

CENTRAL STANDARD TIME.

1922		h	m			1922		h	m		
Mar.	1	18	10	II	Sh. I.	Mar.	17	16	26	I	Ec. D.
		18	11	I	Ec. D.			18	01	II	Ec. D.
		18	39	III	Sh. I.			19	01	I	Oc. R.
		19	40	II	Tr. I.			21	25	II	Oc. R.
		20	45	II	Sh. E.		18	13	42	I	Sh. I.
		21	04	III	Sh. E.			14	06	I	Tr. I.
		21	06	I	Oc. R.			15	54	I	Sh. E.
		21	38	III	Tr. I.			16	17	I	Tr. E.
		22	08	II	Tr. E.		19	12	33	II	Sh. I.
	2	15	26	I	Sh. I.			13	19	II	Tr. I.
		16	10	I	Tr. I.			13	27	I	Oc. R.
		17	38	I	Sh. E.			15	08	II	Sh. E.
		18	20	I	Tr. E.			15	47	II	Tr. E.
	3	15	32	I	Oc. R.			16	32	III	Ec. D.
		16	49	II	Oc. R.			20	08	III	Oc. R.
	5	13	27	III	Oc. R.		23	21	01	I	Sh. I.
	8	20	04	I	Ec. D.			21	24	I	Tr. I.
		20	43	II	Sh. I.		24	18	19	I	Ec. D.
		21	57	II	Tr. I.			20	38	II	Ec. D.
	9	17	19	I	Sh. I.			20	45	I	Oc. R.
		17	55	I	Tr. I.		25	15	36	I	Sh. I.
		19	32	I	Sh. E.			15	50	I	Tr. I.
		20	06	I	Tr. E.			17	48	I	Sh. E.
	10	14	33	I	Ec. D.			18	01	I	Tr. E.
		15	25	II	Ec. D.		26	12	48	I	Ec. D.
		17	17	I	Oc. R.			15	07	II	Sh. I.
		19	08	II	Oc. R.			15	11	I	Oc. R.
	11	14	01	I	Sh. E.			15	33	II	Sh. E.
		14	32	I	Tr. E.			18	02	II	Tr. E.
	12	13	33	II	Tr. E.			20	30	III	Ec. D.
		16	48	III	Oc. R.		27	12	17	I	Sh. E.
	15	21	58	I	Ec. D.			12	27	I	Tr. E.
	16	19	13	I	Sh. I.		28	12	49	II	Oc. R.
		19	24	I	Tr. I.		30	12	53	III	Sh. E.
		21	26	I	Sh. E.			13	05	III	Tr. E.
		21	50	I	Tr. E.		31	20	13	I	Ec. D.

NOTE:—I. denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1922 March							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SY Androm.	0	08.0	+43	09	9.5—13.0	34	21.8					23	10		
RT Sculptor.		31.5	—26	13	9.6—10.5	0	12.3	7	5	14	21	22	13	30	5
UU Androm		38.5	+30	24	10.7—11.9	1	11.7	5	19	13	6	20	16	28	2
U Cephei	0	53.4	+81	20	7.0— 9.0	2	11.8	7	20	15	7	22	19	30	6
Z Persei	2	33.7	+41	46	9.4—12	3	01.4	5	1	11	3	23	9	29	11
TW Cassiop.		37.6	+65	19	8.2— 9.0	1	10.3	4	16	11	20	18	23	26	3
RY Persei		39.0	+47	43	8.0—10.3	6	20.7	3	8	10	5	23	22	30	19
RZ Cassiop.		39.9	+69	13	6.9— 8.1	1	04.7	2	13	9	17	24	1	31	5
TX Cassiop.		44.4	+62	22	9.4—10.1	2	22.2	3	12	12	7	21	2	29	20
ST Persei		53.7	+38	47	8.5—10.5	2	15.6	5	15	13	13	21	12	29	11
RX Cassiop.	2	58.8	+67	11	8.6— 9.1	32	07.6					20	0		
Algol	3	01.7	+40	34	2.3— 3.5	2	20.8	1	20	10	10	19	1	27	15
RT Persei		16.7	+46	12	9.5—11.5	0	20.4	1	9	8	4	14	23	28	13
λ Tauri		55.1	+12	12	3.3— 4.2	3	22.9	5	15	13	13	21	10	29	8
RW Tauri	3	57.8	+27	51	7.1—<11	2	18.5	1	13	9	21	18	4	26	11
RV Persei	4	04.2	+33	59	9.5—11.0	1	23.4	7	6	15	3	23	1	30	22
RW Persei		13.3	+42	04	8.8—11.0	13	04.8	5	20			19	1		
SZ Tauri		31.4	+18	20	7.2— 7.7	3	03.6	5	7	14	18	24	4		
RS Cephei	4	48.6	+80	06	9.5—12.0	12	10.1			12	22			25	8
TT Aurigæ	5	02.8	+39	27	7.8— 8.7	0	16.0	3	10	10	2	23	9	30	1
RY Aurigæ		11.5	+38	13	10.7—11.7	2	17.5			8	7	16	11	24	15
RZ Aurigæ		42.9	+31	40	10.6—13.3	3	00.3	2	7	14	8	20	8	26	9
SV Tauri		45.8	+28	05	9.4—11.0	2	04.0	7	3			15	9	24	11
Z Orionis		50.2	+13	40	9.7—10.7	5	04.9			11	3	21	13	31	22
SV Gemin.		54.6	+24	28	9.8—<11	4	00.2	4	6	12	6	20	7	28	7
RW Gemin.	5	55.4	+23	08	9.5—11.0	2	20.8	5	14	11	7	22	18	28	12
U Columbæ	6	11.2	—33	03	9.2—10.0	2	19.2	1	19	13	0	24	5	29	19
SX Gemin.		22.0	+20	37	10.8—11.5	1	08.8	7	2	15	7	23	12	31	17
RW Monoc		29.3	+ 8	54	9.0—10.8	1	21.7	2	18	10	9	18	0	25	15
RX Gemin.		43.6	+33	21	8.8— 9.6	12	05.0	7	22			20	3		
RU Monoc.	6	49.4	— 7	28	9.8—10.5	0	21.5	7	9	14	13	21	18	28	22
R Can. Maj.	7	14.9	—16	12	5.8— 6.4	1	03.3	4	21	11	17	18	12	25	8
RY Gemin.		21.7	+15	52	8.9—<10	9	07.2	7	7			16	14	25	22
Y Camelop.		27.6	+76	17	9.5—12	3	07.3	1	19	8	10	21	15	27	6
TX Gemin.		30.3	+17	08	10.0—11.9	2	19.2	2	0	10	10	18	20	27	5
RR Puppis		43.5	—41	08	9.4—10.7	6	10.3	3	10	9	20	22	17	29	3
V Puppis	7	55.4	—48	58	4.1— 4.8	1	10.9	1	9	8	15	23	4	30	11
X Carinae	8	29.1	—58	53	7.9— 8.7	0	13.0	2	13	10	15	18	18	26	21
S Cancri	8	38.2	+19	24	8.2—10	9	11.6	4	16	14	4	23	15		
RX Hydræ	9	00 8	— 7	52	9.1—10.5	2	06.8	4	20	11	16	18	13	25	9
S Velorum		29.4	—44	46	7.8— 9.3	5	22.4	6	12	18	9	24	7	30	5
Y Leonis	9	31.1	+26	41	9.3—11.2	1	16.5	5	11	12	5	18	23	25	17
RR Velorum	10	17.8	—41	36	10.0—10.9	1	20.5	3	12	10	22	18	6	25	19
SS Carinæ	10	54.2	—61	23	12.2—12.8	3	07.2	4	18	11	9	24	14	31	4
ST Urs. Maj.	11	22.4	+45	44	6.7— 7.2	8	19.2	7	15			16	16	25	0
RW Urs. Maj.		35.4	+52	34	10.3—11.4	7	07.9	6	12	13	20	21	4	28	12
Z Draconis	11	39.8	+72	49	9.9—13.6	1	08.6	3	6	10	1	18	20	25	15
RZ Centauri	12	55.6	—64	05	8.5— 8.9	1	21.0	6	8	13	20	21	8	28	20
RS Can. Ven.	13	06.3	+36	28	7.5—12.5	4	19.1	4	4	13	19	23	9		
SS Centauri		07.2	—63	37	8.8—10.4	2	11.5	1	5	8	15	16	17	23	12
133926 Hydræ	13	39.0	—26	23	8.6—12.7	2	21.5	4	18	10	13	22	3	27	22

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period	Greenwich mean times of minima in 1922							
							March							
	h	m	°	′		d h	d	h	d	h	d	h	d	h
δ Libræ	14	55.6	—	8 07	4.8— 6.2	2 07.9	3	1	9	22	23	16	30	13
U Coronæ	15	14.1	+32	01	7.6— 8.7	3 10.9	6	19	13	16	20	14	27	12
TW Draconis		32.4	+64	14	7.3— 8.9	2 19.3	2	6	10	16	19	2	27	12
SS Librae	15	43.4	—15	14	9.3—11.5	0 18.4	8	15	16	6	23	22	31	15
SW Ophiuchi	16	11.1	—	6 44	9.2—10.0	2 10.7	2	14	9	22	17	6	31	23
SX Ophiuchi		12.6	—	6 25	10.5—11.2	2 01.5	2	1	10	7	18	13	26	19
R Aræ		31.1	—56	48	6.8— 7.9	4 10.2			9	5	18	2	26	22
TT Herculis	16	49.9	+17	00	8.9— 9.3	20 18.1					20	9		
TU Herculis	17	09.8	+30	50	9.5—12	2 06.4	6	20	13	15	20	10	27	6
U Ophiuchi		11.5	+	1 19	6.0— 6.7	0 20.1	5	3	13	12	21	22	30	7
u Herculis		13.6	+33	12	4.6— 5.4	2 01.2	4	3	16	11	22	14	28	18
TX Herculis		15.4	+42	00	8.3— 9.0	1 00.7	3	21	16	6	22	10	28	14
RV Ophiuchi		29.8	+	7 19	9. —12	3 16.5	5	21	13	6	20	14	27	23
SZ Herculis		36.0	+33	01	9.5—10.3	0 19.6	3	10	11	15	19	19	28	23
TX Scorpii		48.6	—34	13	7.5— 8.2	0 22.6	2	2	9	15	17	4	24	16
UX Herculis		49.7	+16	57	8.8—10.5	1 13.2	1	1	9	19	16	13	24	7
Z Herculis		53.6	+15	09	7.1— 7.9	3 23.8	6	4	14	4	22	3	30	3
WX Sagittarii		53.6	—17	24	9.2—10.8	2 03.1	2	9	10	22	19	10	28	22
WY Sagittarii	17	54.9	—23	01	9.5—10.6	4 16.0			8	18	18	3	27	11
SX Draconis	18	03.0	+58	23	9.3—10.5	5 04.1	4	13	14	21			25	5
RS Sagittarii		11.0	—34	08	5.9— 6.3	2 10.0	1	21	8	23	23	10	30	16
V Serpentis		11.1	—15	34	9.5—11.1	3 10.9	5	0	11	22	18	19	25	17
RZ Scuti		21.1	—	9 15	7.4— 8.3	15 03.2	5	18			20	21		
RZ Draconis		21.8	+58	50	9.5—10.2	0 13.2	5	6	12	10	19	13	28	18
RX Herculis		26.0	+12	32	7.0— 7.6	0 21.3	3	23	11	1	18	4	25	7
SX Sagittarii		39.7	—30	36	8.7— 9.8	2 01.8	1	19	10	2	18	9	26	17
RR Draconis		40.8	+62	34	9.3—13	2 19.9	2	8	10	19	19	7	27	19
RS Scuti		43.7	—10	21	9.3—10.3	0 15.9	3	14	10	5	23	12	30	4
β Lyræ		46.4	+33	15	3.4— 4.1	12 21.8	1	20	14	17	27	15		
U Scuti	18	48.9	—12	44	9.1— 9.6	0 22.9	3	15	11	6	18	22	26	13
RX Draconis	19	01.1	+58	35	9.3—10.2	1 21.4	3	13	11	3	18	17	26	7
RV Lyræ		12.5	+32	15	11. —12.8	3 14.4	1	8	8	13	15	18	30	3
RS Vulpec.		13.4	+22	16	6.9— 8.0	4 11.4	8	11			17	10	26	9
U Sagittæ		14.4	+19	26	6.5— 9.0	3 09.1	6	20	13	14	20	9	27	3
Z Vulpec.		17.5	+25	23	7.3— 8.5	2 10.9	5	6	12	15	20	0	27	8
TT Lyræ		24.3	+41	30	9.4—11.6	5 05.8	1	7	11	18	22	6	27	12
UZ Draconis		26.1	+68	44	9.0— 9.8	1 15.1	6	23	13	12	20	0	26	12
SY Cygni	19	42.7	+32	28	10 —12	6 00.2	5	19	11	19	23	19	29	19
WW Cygni	20	00.6	+41	18	9.3—13.4	3 07.6	1	18	8	9	21	16	28	7
SW Cygni		03.8	+46	01	9. —11.7	4 13.8			9	12	18	16	27	19
VW Cygni		11.4	+34	12	9.8—11.8	8 10.3	4	4	12	15	21	1	29	11
RW Capric.		12.2	—17	59	8.8—10.6	3 09.4	3	3	9	21	23	11	30	6
UW Cygni		19.6	+42	55	10.5—13	3 10.8	6	6	13	4	20	1	26	23
V Vulpec.		32.3	+26	15	8.2— 9.8	37 19.0					24	1		
W Delphini		33.1	+17	56	9.4—12.1	4 19.4	5	16	15	7	24	21		
RR Delphini		38.9	+13	35	10.5—11.8	4 14.4	4	11	13	16	22	20		
Y Cygni		48.1	+34	17	7.1— 7.9	1 12.0	4	20	12	7	19	19	27	7
WZ Cygni		49.3	+38	27	9.9—10.8	0 14.0	1	13	9	3	16	18	24	8
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5 01.2	1	13	11	16	21	19	31	21
VVCygni	21	02.3	+45	23	12.1—13.8	1 11.4	5	17	13	2	20	11	27	20
AE Cygni		09.0	+30	20	10.8—11.4	0 23.3	4	17	14	10	24	3		
RY Aquarii		14.8	—11	14	8.8—10.4	1 23.2	1	23	9	20	17	17	25	13
RT Lacertæ	21	57.4	+43	24	9.1—10.5	5 01.7	3	8	13	11	23	15		
UZ Cygni		55.2	+43	52	8.9—11.6	31 07.3					17	12		
RW Lacertæ	22	40.6	+49	08	10.2—11.2	5 04.4	2	9	12	18	23	3	28	8
8.1914 Pegasi		51.7	+32	41	10.0—10.6	5 06.4	1	2	16	21	22	4	27	10
TT Androm.	23	08.7	+45	36	11.3—12.6	2 18.4	7	18	16	1	24	8		
Y Piscium		29.3	+	7 22	9.0—12.0	3 18.3	5	5	12	17	20	6	27	19
TW Androm.	23	58.2	+32	17	8.6—11.5	4 02.9	4	23	13	5	21	10	29	16

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1922 March							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SX Cassiop.	0	05.5	+54	20	8.6— 9.2	36	13.7							27	11
SY Cassiop.	0	09 8	+57	52	9.3— 9.9	4	01.7	7	0	15	4	23	7	31	10
RR Ceti	1	27.0	+ 0	50	8.3— 9.0	0	13.3	7	6	15	0	22	18	30	12
RW Cassiop.	1	30.7	+57	15	8.9—11.0	14	19.2	1	17	16	12			31	7
V Arietis	2	09.6	+11	46	8.3— 9.0	0	23.8	2	9	10	8	18	6	26	5
SU Cassiop.	2	43.0	+68	28	6.5— 7.0	1	22.8	8	15	16	10	24	5		
TU Persei	3	01.8	+52	49	11.4—12.2	0	14.6	2	23	10	6	17	12	24	19
RW Camelop.	3	46.2	+58	21	8.2— 9.4	16	00.0	7	0			23	0		
SX Persei	4	10.2	+41	27	10.4—11.2	4	07.0	8	6			16	20	25	10
SV Persei		42.8	+42	07	8.8— 9.6	11	03.1	3	3	14	6	25	10		
RX Aurigæ	4	54.5	+39	49	7.2— 8.1	11	15.0	3	5	14	19			26	11
SX Aurigæ	5	04.6	+42	02	8.0— 8.7	1	12.8	8	5	15	21	23	13	31	5
SY Aurigæ		05.5	+42	41	8.4— 9.5	10	03.3			10	22	21	1	31	4
Y Aurigae		21.5	+42	21	8.6— 9.6	3	20.6	2	8	10	1	17	18	25	12
RZ Gemin.	5	56.6	+22	15	9.1—10.0	5	12.7	4	21	9	22	20	23	26	12
RS Orionis	6	16.5	+14	44	8.2— 8.9	7	13.6	3	5	10	18	18	8	25	22
T Monoc.		19.8	+ 7	08	5.7— 6.8	27	00.3			15	17				
RT Aurigæ		23.0	+30	33	5.1— 6.0	3	17.5	1	23	9	11	16	21	31	20
RZ Camelop.		23.7	+67	06	11.0—13.0	0	11.5	7	1	14	5	21	10	28	15
W Gemin.		29.2	+15	24	6.7— 7.5	7	22.0	7	18	15	16	23	14	31	12
ζ Gemin.	6	58.2	+20	43	3.7— 4.3	10	03.7	5	15	15	19	25	23		
RU Camelop.	7	10.9	+69	51	8.5— 9.8	22	06.5	6	17					28	23
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	2	8	10	6	18	5	26	4
V Carinæ	8	26.7	—59	47	7.4— 8.1	6	16.7	7	4	13	20	20	14	27	6
T Velorum	8	34.4	—47	01	7.6— 8.5	4	15.3	8	20	18	2			27	9
V Velorum	9	19.2	—55	32	7.5— 8.2	4	08.9	2	13	11	7	20	1	28	19
Z Leonis	9	46.4	+27	22	7.9— 9.6	59	00.0					21			
RR Leonis	10	02.1	+24	29	9.1—10.1	0	10.9	2	18	9	13	23	3	29	22
SU Draconis	11	32.2	+67	53	8.9— 9.6	0	15.8	4	2	17	7	23	22	30	12
S Muscæ	12	07.4	—69	36	6.4— 7.3	9	15.8	7	18			17	10	27	1
SW Draconis		12.8	+70	04	8.8— 9.6	0	13.7	4	23	12	23	20	22	28	21
T Crucis		15.9	—61	44	6.8— 7.6	6	17.6	6	10	13	4	19	21	26	15
R Crucis		18.1	—61	04	6.8— 7.9	5	19.8	4	3	9	22	21	14	27	10
S Crucis	12	48.4	—57	53	6.5— 7.6	4	16.6	3	0	12	9	21	18	31	3
W Virginis	13	20.9	— 2	52	8.7—10.4	17	06.5	8	17			26	0		
SS Hydræ		25.0	—23	08	7.4— 8.1	8	04.8	4	19	13	0	21	5	29	10
RV Urs. Maj.	13	29.4	+54	31	9.2— 9.9	0	11.2	6	2	13	2	20	3	27	3
ST Virginis	14	22.5	— 0	27	10.3—11.4	0	09.9	5	8	13	13	21	18	29	23
V Centauri		25.4	—56	27	6.4— 7.8	5	11.9	4	2	9	14	20	14	31	14
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	3	13	11	3	18	16	26	5
RU Bootis	14	41.5	+23	44	12.8—14.3	0	11.9	7	19	15	5	22	15	30	1
R Triang. Austr.	15	10.8	—66	08	6.7— 7.4	3	09.3	1	7	8	2	21	15	28	10
S Triang Austr.	15	52.2	—63	29	6.4— 7.4	6	07.8	2	23	9	7	21	23	28	6
S Normæ	16	10.6	—57	39	6.6— 7.6	9	18.1			10	1	19	19	29	13
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	7	4	16	1			24	22
RV Scorpii	16	51.8	—33	27	6.7— 7.4	6	01.5	5	2	17	5	23	6	29	8
X Sagittarii	17	41.3	—27	48	4 4— 5.0	7	00.3	4	14	11	15	18	15	25	15
Y Ophiuchi		47.3	— 6	07	6.1— 6.5	17	02.9			13	0			30	3
W Sagittarii	17	58.6	—29	35	4.3— 5.1	7	14.3	5	10	13	1	20	15	28	5
Y Sagittarii	18	15.5	—18	54	5.4— 6.2	5	18.6	5	2	10	20	22	9	28	4
U Sagittarii		26.0	—19	12	6.5— 7.3	6	17.9	2	9	9	3	22	15	29	9
Y Scuti		32.6	— 8	27	8.7— 9.2	10	08.3	1	6	11	14	21	22		
Y Lyræ		34.2	+43	52	11.3—12.3	0	12.1	5	16	11	17	23	19	29	19
RZ Lyræ	18	39.9	+32	42	9.9—11.2	0	12.3	5	5	11	8	23	14	29	18

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1922 March					
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	3 16	15 14	21 12	27 11		
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	6 20	15 22		25 2		
U Aquilæ	19 24.0	− 7 15	6.2— 6.9	7 00.6	1 9	15 10	22 11	29 11		
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	7 16	14 15	21 15	28 15		
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	7 22	15 22	23 21	31 21		
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	2 23	10 15	18 8	26 1		
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	1 23	16 7	23 11	30 16		
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2		9 1	17 10	25 19		
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	5 14	11 21	18 5	30 20		
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	4 19		21 4			
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	1 16	10 13	19 10	28 6		
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	6 2	12 19	19 13	26 6		
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	7 9	14 2	20 19	27 13		
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4		10 18		25 12		
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	8 1	15 22	23 18	31 15		
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	3 11	10 8	24 3	31 0		
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	3 10	13 3	22 21	27 18		
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8	3 16	12 8	20 23	29 15		
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	2 5	12 22	23 15	29 0		
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1	7 5		18 2	28 23		
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1	6 1	18 22	25 8	31 18		
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	1 5	11 4	21 4	29 3		
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	6 16	12 2	23 0	28 11		
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	4 15	15 12	26 10	31 20		
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	5 10	18 0	24 7	30 14		
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	8 13		20 17			
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	2 3	16 3	23 2	30 2		

Monthly Report of the American Association of Variable Star Observers, November 20 to December 20, 1921.

The proposed Edward C. Pickering Memorial has been submitted to many of the prominent astronomers of America, and it is almost universally agreed that any memorial to this distinguished astronomer should be in some way intimately associated with the Harvard Observatory. It has been decided, therefore, by the committee, that a memorial fund shall be raised for the endowment of variable star work at the Harvard Observatory under the auspices of the Association, rather than for the erection of a separate variable star observatory, as at first suggested.

Mr. Eaton has left Germany and is travelling through France, Switzerland, and Italy, and will meet several members of the Association.

Mr. W. J. Fisher leaves soon for Honolulu where he expects to use for variable star observations the 6″ glass at the Hawaii College.

The Association has sustained another loss in the death on December 12 of Miss Henrietta S. Leavitt, an Honorary Member. She was keenly interested in the Association and was an authority on variable stars, especially as studied photographically.

The following members contributed to this report: Messrs. Bouton "B," Brocchi "Br," Chandra "Ch," Miss Clough "Cg," Delmhorst "De," Fisher "Fi,"

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1921.

November 0 = J. D. 2422994 December 0 = J. D. 2423024

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
001046 X ANDROMEDAE—												
	3006.7	9.1	Ml,	3012.6	9.5	B,	3024.8	9.3	M,	3038.6	9.5	B.
001032 S SCULPTORIS—												
	3023.7	6.4	Pt.									
001620 T CETI—												
	3019.4	6.5	L.									
001755 T CASSIOPEIAE—												
	2969.1	11.9	Ch,	2999.0	11.3	Jk,	3012.4	11.3	L,	3019.5	11.0	Gi,
	3024.8	<11.3	M,	3026.6	9.8	B.						
001726 T ANDROMEDAE—												
	2969.1	11.2	Ch,	2993.1	9.3	Ch,	3023.7	8.9	Pt,	3036.6	8.8	B.
001838 R ANDROMEDAE—												
	2982.1	<12.0	Ch,	2989.0	11.2	Ym,	2993.1	11.4	Ch,	3023.7	8.1	Pt,
	3038.6	7.6	B,	3042.5	7.4	Ya.						
001909 S CETI—												
	2970.2	<11.5	Ch,	3012.3	12.2	L,	3017.4	<11.8	Rk,	3018.4	12.1	Rk,
	3026.6	<11.5	Mu,	3027.5	11.9	Ya.						
004047 U CASSIOPEIAE—												
	3006.7	8.1	Ml,	3011.6	8.0	B,	3015.7	8.4	Hj,	3019.6	8.3	Y,
	3023.7	8.5	Pt,	3024.8	8.5	M,	3036.6	8.7	B.			
004746a RV CASSIOPEIAE—												
	3000.7	<13.2	L,	3019.4	<14.0	L,	3023.4	13.7	L.			
004958 W CASSIOPEIAE—												
	3011.6	9.0	B,	3015.6	9.7	Lc,	3020.4	9.2	Rk,	3023.4	8.9	Gi,
	3023.7	9.0	Pt,	3024.5	9.4	Gd,	3025.6	9.0	Hu,	3038.6	8.9	B.
010102 Z CETI—												
	3019.7	10.8	B,	3026.5	11.7	B.						
010940 U ANDROMEDAE—												
	3019.7	13.4	B.									
011272 S CASSIOPEIAE—												
	2999.4	8.7	Rk,	3012.6	8.7	B,	3017.4	8.7	Rk,	3024.8	8.6	Pt.
011208 S PISCIUM—												
	3022.6	13.3	B,	3026.6	13.7	B,	3043.6	<13.0	Y.			
012350 RZ PERSEI—												
	3043.6	12.1	Y.									
012502 R PISCIUM—												
	3004.4	11.5	Rk,	3018.4	11.6	Rk,	3029.6	<13.1	Y.			
013238 RU ANDROMEDAE—												
	2982.1	<11.5	Ch,	3019.7	<13.5	B.						
013338 Y ANDROMEDAE—												
	2972.5	10.0	Ch,	2993.1	8.7	Ch,	3023.7	9.6	Pt,	3024.6	9.8	B.
014958 X CASSIOPEIAE—												
	3023.7	12.6	Pt.	3024.6	11.6	B,	3024.8	<11.6	M,	3025.5	12.3	Y.
015354 U PERSEI—												
	2998.0	9.9	Jk,	3015.6	9.8	Pt,	3024.8	9.0	M,	3030.6	9.0	B.
015912 S ARIETIS—												
	3015.6	12.0	Pt,	3030.5	13.0	B.						
021024 R ARIETIS—												
	2991.0	7.7	Ym,	2998.3	8.1	L,	3015.4	8.1	Gi,	3015.6	8.2	Pt,
	3024.8	8.5	M,	3029.6	8.8	Br,	3043.6	10.0	Ya.			
021143a W ANDROMEDAE—												
	3015.7	9.1	Gi.									
021258 T PERSEI—												
	2996.0	9.1	Jk,	3031.6	8.0	Hu.						
021381 Z CEPHEI—												
	3019.7	<13.5	B.									
021403 o CETI—												
	2970.2	8.3	Ch,	2991.0	8.5	Ym,	2993.1	8.8	Ch,	3012.3	8.8	L,
	3015.6	8.9	Pt,	3019.4	9.1	L,	3026.6	9.0	Mu,	3027.5	9.1	O,
	3027.6	9.5	Ya,	3027.7	9.3	Br,	3030.6	8.9	Hu.			

VARIABLE STAR OBSERVATIONS. November 20 to December 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
021558 S PERSEI—												
	2996.0	9.5	Jk,	3024.6	8.6	B,	3024.8	9.1	M,	3031.6	8.5	Hu.
022000 R CETI—												
	3021.5	7.9	O.									
022150 RR PERSEI—												
	3019.6	13.0	Y.									
022813 U CETI—												
	2970.2	10.2	Ch,	3019.6	12.6	Y,	3023.5	12.5	Pt,	3030.6	12.5	B.
023080 RR CEPHEI—												
	3022.3	<13.4	L.									
023133 R TRIANGULI—												
	2998.0	10.2	Jk,	3004.4	9.7	Rk,	3017.6	9.4	Pt,	3020.4	9.0	Rk,
	3024.6	8.8	B.									
024356 W PERSEI—												
	3023.5	9.4	Pt,	3024.5	9.4	B,	3024.5	9.2	Gd,	3024.8	9.8	M,
	3029.7	9.3	Br,	3030.6	9.3	Hu,	3043.6	9.4	Ya.			
030514 U ARIETIS—												
	3015.4	<13.8	Gi,	3019.6	<13.1	Y,	3026.6	<14.5	B.			
031401 X CETI—												
	3019.4	12.0	L,	3023.6	11.7	Pt,	3026.6	11.8	B.			
032043 Y PERSEI—												
	3023.6	8.0	Pt,	3024 8	9.4	M.	3026.6	8.8	Mu,	3030.6	9.0	B,
	3030.6	8.6	Hu,	3043.6	9.4	Ya.						
032335 R PERSEI—												
	3019.4	13.7	Gi,	3022.6	13.5	B.						
032443 NOVA PERSEI #2—												
	3019.4	13.1	Gi.									
040725 W ERIDANI—												
	3008 8	8.6	Ml.									
042215 W TAURI—												
	3022.6	9.3	B,	3023.6	9.9	Pt,	3024.5	10.4	O,	3026.6	10.3	Mu,
	3027.6	10.0	Br,	3030.6	9.0	Hu,	3031.5	9.7	O,	3038.6	9.3	B,
	3042.5	9.7	O.									
042209 R TAURI—												
	3023.6	10.5	B,	3023.6	11.3	Pt,	3038.6	11.2	B,	3042.5	11.8	O.
042309 S TAURI—												
	3023.6	12.5	B,	3038.6	<12.0	B,	3042.6	<11.5	O.			
043065 T CAMELOPARDALIS—												
	3022.3	13.0	L.									
043274 X CAMELOPARDALIS—												
	2994 2	11.2	Ch,	2998.9	<11.1	Jk,	3004.4	12.1	Rk,	3012.6	12.9	B,
	3017.4	<12.3	Rk,	3023.6	12.8	Pt,	3025.7	12.5	Y.			
043208 RX TAURI—												
	3022.6	13.0	B,	3024.5	<11.9	O.						
044617 V TAURI—												
	3015.6	<11.5	Lc,	3023.6	11.9	Pt,	3023.7	12.1	B,	3042.5	10.8	O.
045307 R ORIONIS—												
	2997.7	11.2	Gi,	3023.4	11.9	Gi,	3023.7	11.8	B,	3029.6	12.3	Y.
045514 **R LEPORIS—**												
	2970.3	9.3	Ch,	2994.2	9 7	Ch,	3000.7	9.5	L,	3018.7	10.0	L,
	3023.7	10.3	Pt,	3034.7	9.2	B,	3042.6	10.3	Ya.			
050003 V ORIONIS—												
	3026.7	10.8	B,	3029.6	10.5	Y.						
050022 T LEPORIS—												
	3023.7	9.4	Pt,	3034 7	8.3	B.						
050953 R AURIGAE—												
	3023.6	11.6	Pt,	3030.6	10.6	B,	3043.6	<11.0	Ya.			
052036 W AURIGAE—												
	3019.4	13.6	Gi,	3022.7	<13.0	B,	3023.4	<12.5	L.			
052034 S AURIGAE—												
	3022.3	9 9	L,	3023.4	8.9	L,	3026.7	9.0	B,	3043.6	9.3	Ya.

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
052404 S ORIONIS—												
	3024.6	11.6	B.									
053068 S CAMELOPARDALIS—												
	3023.6	8.4	Pt.									
053005a T ORIONIS—												
	3000.7	10.3	L,	3012.6	10.2	B,	3018.7	10.1	L,	3022.7	9.9	L,
	3023.4	9.9	L,	3023.6	10.0	Pt,	3024.7	9.9	L.			
053326 RR TAURI—												
	3026.6	12.5	B.									
053531 U AURIGAE—												
	3022.7	<13.0	B,	3029.7	<13.0	Y.						
054319 SU TAURI—												
	2970.3	9.7	Ch,	2990.1	9.5	Ym,	2994.2	9.1	Ch,	3000.7	9.4	L,
	3004.4	9.3	Rk,	3017.4	9.3	Rk,	3017.6	9.4	Pt,	3018.7	9.5	L,
	3022.3	9.4	L,	3023.6	9.6	Pt,	3023.7	9.3	De,	3023.7	9.5	B,
	3024.8	9.5	Pt,	3025.6	9.6	O,	3029.7	9.4	Y,	3030.6	9.5	B,
	3032.5	9.5	O,	3034.6	9.5	B,	3034.9	9.5	Pt,	3042.5	9.6	O.
054615a Z TAURI—												
	3029.7	<12.7	Y.									
054974 V CAMELOPARDALIS—												
	2990.1	11.1	Ym,	3022.4	11.6	Gi,	3023.6	11.9	Pt,	3024.6	11.8	B,
	3029.7	11.9	Y.									
054920 U ORIONIS—												
	2990.1	8.3	Ym,	2994.2	8.4	Ch,	3023.6	9.0	Pt,	3025.6	9.0	O,
	3026.6	8.8	B,	3030.6	8.9	Hu,	3032.5	9.4	O,	3042.5	9.3	O,
	3044.6	<9.9	Cg.									
055353 Z AURIGAE—												
	3023.6	9.9	Pt,	3024.6	9.8	B.						
060450 X AURIGAE—												
	2970.3	8.6	Ch,	2990.2	8.7	Ch,	3019.5	11.5	Ro,	3023.6	11.6	Pt,
	3031.7	11.9	B.									
060547 SS AURIGAE—												
	2969.4	10.5	Ch,	2989.0	<12.4	Ym,	2990.1	<13.3	Ym,	2990.2	<11.5	Ch.
	2997.7	<13.9	Gi,	3000.7	<13.3	L,	3011.3	<12.4	L,	3011.6	<13.5	Gi,
	3012.4	<12.4	L,	3014.5	<12.4	O,	3015.4	<13.9	Gi,	3015.6	<11.0	Pt,
	3016.7	<13.9	Gi,	3017.6	<12.6	Pt,	3018.7	<13.3	L,	3019.4	14.0	Gi,
	3019.4	<13.9	L,	3019.6	<13.3	Y,	3020.4	<11.6	Rk,	3022.2	<12.4	L,
	3022.4	<13.9	Gi,	3022.7	<13.7	B,	3023.4	<13.9	Gi,	3023.4	<13.9	L,
	3023.6	<12.6	Pt,	3024.4	<13.9	Gi,	3024.4	<11.6	Rk,	3024.6	<13.5	B,
	3024.7	<14.5	L,	3024.8	<12.6	Pt,	3028.5	<12.4	Pt,	3029.7	<13.3	Y,
	3030.5	11.9	Pt,	3030.6	11.4	B,	3031.5	10.8	O,	3031.6	10.8	De,
	3031.6	10.9	B,	3032.5	11.0	O,	3033.6	11.2	De,	3034.6	12.6	B,
	3034.9	12.0	Pt,	3036.6	<13.0	B,	3042.5	<11.0	O.			
063159 U LYNCIS—												
	3029.7	13.0	Y,	3031.6	13.8	B.						
063658 S LYNCIS—												
	3023.7	11.9	Pt,	3030.6	12.6	B.						
064030 X GEMINORUM—												
	3019.5	12.5	Gi.									
064707 W MONOCEROTIS—												
	3023.7	10.6	Pt.									
064932 NOVA GEMINORUM #2—												
	3022.7	14.0	L.									
065111 Y MONOCEROTIS—												
	3019.6	13.0	Y.									
065208 X MONOCEROTIS—												
	3000.7	7.3	L,	3024.7	7.6	L.						
065355 R LYNCIS—												
	2997.7	12.7	Gi,	3023.4	12.8	Gi,	3029.7	<13.5	Y.			
070122a R GEMINORUM—												
	2972.4	7.4	Ch,	2994.2	7.0	Ch,	3023.7	7.1	Pt.			

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
070122b Z GEMINORUM—												
	3023.7	12.6	Pt.									
070310 R CANIS MINORIS—												
	3018.7	10.0	L.									
072708 S CANIS MINORIS—												
	2972.4	10.5	Ch,	3018.7	12.7	L,	3024.4	<10.0	Rk,	3024.8	12.4	Pt.
072811 T CANIS MINORIS—												
	3024.8	12.4	Pt.									
073508 U CANIS MINORIS—												
	3018.7	8.9	L,	3023.7	9.2	Pt,	3029.7	9.0	Y,	3043.6	9.2	Y.
073723 S GEMINORUM—												
	3024.6	12.1	O.									
074323 T GEMINORUM—												
	3024.6	10.8	O.									
074922 U GEMINORUM—												
	2997.7	10.4	Gi,	3000.6	12.8	L,	3011.6	<13.3	Gi,	3015.7	<13.7	Gi,
	3016.7	14.0	Gi,	3018.7	<13.3	L,	3019.4	<13.7	L,	3019.5	13.9	Gi,
	3019.6	<12.0	M,	3022.5	14.0	Gi,	3022.7	<13.7	L,	3023.4	13.9	Gi,
	3023.4	<13.3	L,	3023.7	<13.3	Pt,	3024.4	13.9	Gi,	3024.4	<11.7	Rk,
	3024.6	<12.4	O,	3024.8	<13.3	Pt,	3029.7	<13.3	Y,	3034.9	<13.3	Pt,
	3042.5	<12.4	O,	3043.6	<13.7	Y.						
075612 U PUPPIS—												
	3029.7	<12.0	Y.									
081112 R CANCRI—												
	2972.4	11.0	Ch,	3000.7	11.5	L,	3024.7	11.2	L,	3024.8	11.1	Pt.
081617 V CANCRI—												
	3015.7	9.4	Gi,	3024.8	9.1	Pt.						
082405 RT HYDRAE—												
	3022.7	8.1	L.									
083350 X URSAE MAJORIS—												
	3008.8	10.3	Ml,	3024.8	9.5	Pt,	3044.6	<9.6	Cg.			
084803 S HYDRAE—												
	2972.4	11.0	Ch,	3024.8	13.2	Pt.						
085008 T HYDRAE—												
	2972.4	10.5	Ch,	3022.7	12.5	L,	3024.8	12.8	Pt.			
085120 T CANCRI—												
	3000.7	9.3	L,	3024.7	8.8	L,	3024.8	9.0	Pt.			
090425 W CANCRI—												
	3000.7	9.2	L,	3024.7	8.3	L.						
093178 Y DRACONIS—												
	3019.6	10.8	Y.									
093934 R LEONIS MINORIS—												
	2972.4	<11.0	Ch,	3018.7	12.0	L,	3024.8	11.6	Pt.			
094211 R LEONIS—												
	2972.4	8.3	Ch,	3024.8	5.7	Pt						
094512 X LEONIS—												
	3000.7	12.0	L.									
095421 V LEONIS—												
	3024.8	9.0	Pt.									
103212 U HYDRAE—												
	3022.7	5.0	L.									
103769 R URSAE MAJORIS—												
	2972.4	7.4	Ch,	3024.8	9.4	Pt.						
104620 V HYDRAE—												
	3022.7	6.6	L.									
121418 R CORVI—												
	3024.7	<11.7	L.									
122001 SS VIRGINIS—												
	3022.7	6.1	L.									
122532 T CANUM VENATICORUM—												
	3024.8	8.6	Pt.									

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
122803 Y VIRGINIS—												
	3022.7	<13.0	L.									
123160 T URSAE MAJORIS—												
	3024.8	9.5	Pt,	3044.6	9.4	Cg.						
123307 R VIRGINIS—												
	3018.7	9.6	L,	3034.9	8.1	Pt.						
123459 RS URSAE MAJORIS—												
	3024.8	12.7	Pt,	3044.6	9.5	Cg.						
123961 S URSAE MAJORIS—												
	2998.2	11.2	L,	3024.7	11.6	L.,	3024.8	11.5	Pt,	3044.6	9.2	Cg.
124204 RU VIRGINIS—												
	3034.9	12.5	Pt.									
124606 U VIRGINIS—												
	3034.9	8.0	Pt.									
132422 R HYDRAE—												
	3022.7	4.8	L,	3023.7	4.8	Gi,	3034.9	4.0	Pt.			
132706 S VIRGINIS—												
	3034.9	10.9	Pt.									
134440 R CANUM VENATICORUM—												
	3034.9	11.3	Pt.									
141567 U URSAE MINORIS—												
	2995.0	11.5	Ch,	3034.9	11.5	Pt.						
141954 S BOOTIS—												
	2998.2	8.3	L,	3022.7	9.2	Gi,	3024.7	9.7	L,	3034.9	9.5	Pt.
142584 R CAMELOPARDALIS—												
	3022.4	11.4	Gi.									
142539 V BOOTIS—												
	2998.2	9.9	L,	3024.7	10.0	L,	3034.9	10.5	Pt.			
143227 R BOOTIS—												
	3034.9	7.7	Pt.									
144918 U BOOTIS—												
	3022.7	11.5	Gi.									
151731 S CORONAE BOREALIS—												
	2985.0	<12.3	Ch,	2993.0	11.9	Ch,	3034.9	8.0	Pt.			
151714 S SERPENTIS—												
	3022.7	12.9	L.									
153378 S URSAE MINORIS—												
	2985.5	9.5	Ro,	2993.5	10.0	Ro,	2997.7	10.2	Ro,	3019.5	10.8	Ro,
	3026.6	11.0	Mu,	3027.5	10.8	Ro.	3030.5	10.8	Pt.			
154428 R CORONAE BOREALIS—												
	2952.9	7.4	Ik,	2969.1	9.5	Ch,	2982.0	9.1	Ch,	2993.0	7.8	Ch,
	2998.2	**7.5**	**L,**	**3000.2**	**7.4**	**L,**	3011.6	6.5	Mu,	3012.2	6.7	Gi,
	3013.6	6 5	Mu,	3014.6	6.4	Mu,	3018.6	6.3	Br,	3018.7	6.2	L,
	3022 7	6.2	L.,	3023.7	6.5	Gi.	3024.7	6.3	L,	3028.5	5.7	Pt,
	3034.9	6.0	Pt.									
154639 V CORONAE BOREALIS—												
	3034.9	7.0	Pt.									
155847 X HERCULIS—												
	3011.6	6.1	Mu,	3013.6	6.1	Mu,	3014.6	6.4	Mu,	3022.6	6.5	Mu,
	3026.6	6.5	Mu,	3027.6	6.6	Mu.						
160118 R HERCULIS—												
	2985.1	<11.5	Ch.									
160625 RU HERCULIS—												
	3034.9	9.2	Pt.									
161138 W CORONAE BOREALIS—												
	3025.5	10.2	Y.									
162119 U HERCULIS—												
	2983.0	11.5	Ch,	3012.3	10.8	Gi,	3022.3	10.5	Gi,	3034.9	10.0	Pt.
162807 SS HERCULIS—												
	2998.2	8.9	L.									
163137 W HERCULIS—												
	2983.1	11.0	Ch,	3025.5	12.4	Y.						

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
163266 R DRACONIS—												
	2994.0	10.9	Ch,	3025.5	12.0	Y,	3030.5	12.4	Pt.			
164715 S HERCULIS—												
	2985.1	10.0	Ch,	3012.3	8.7	Gi,	3022.2	8.5	Gi.			
165631 RV HERCULIS—												
	2991.0	11.2	Ym.									
171401 Z OPHIUCHI—												
	3015.2	9.5	Gi.									
175458a T DRACONIS—												
	3022.4	12.2	Gi.									
175519 RY HERCULIS—												
	2984.1	<12.1	Ch,	3028.5	12.5	Pt.						
180565 W DRACONIS—												
	3028.5	11.8	Pt.									
180531 T HERCULIS—												
	2984.1	10.9	Ch,	2998.3	9.3	L,	3022.2	8.0	L,	3028.5	7.8	Pt.
180911 NOVA OPHIUCHI #4—												
	3015.3	12.1	Gi.									
181031 TV HERCULIS—												
	3011.3	9.1	L,	3022.2	9.1	L.						
181136 W LYRAE—												
	2998.3	9.8	L,	2998.9	9.9	Jk,	3006.6	9.6	Hj,	3014.5	9.5	Hj,
	3019.5	9.2	Hj,	3025.5	8.9	Y,	3025.6	9.0	Hu,	3028.5	9.2	Pt.
181103 RY OPHIUCHI—												
	2959.0	9.6	Jk,	3012.3	13.4	Gi,	3022.3	13.4	Gi.			
182224 SV HERCULIS—												
	3012.3	12.4	L.									
183149 SV DRACONIS—												
	3025.5	10.9	Y.									
183225 RZ HERCULIS—												
	3025.5	<12.0	Y.									
183308 X OPHIUCHI—												
	3012.3	8.7	L.									
184243 RW LYRAE—												
	3012.5	13.9	B.									
***184205* R SCUTI—**												
	2984.2	5.0	Ch,	2985.5	5.3	Ro,	2990.9	5.0	Ym,	2993.5	5.2	Ro,
	2997.5	5.2	Ro,	3006.6	5.8	Hj,	3011.3	5.8	Gi,	3011.6	5.8	Mu,
	3012.3	5.7	L.	3013.6	5.9	Mu,	3014.5	5.9	Hj,	3014.6	5.9	Mu,
	3015.5	5.6	Pt,	3018.6	5.8	Br,	3019.5	6.0	Hj,	3022.2	6.2	L,
	3022.6	6.5	Mu,	3023.2	6.5	Gi,	3026.6	6.5	Mu,	3027.6	6.3	Mu,
	3028.5	6.2	Pt,	3030.5	5.8	Pt.						
184300 NOVA AQUILAE #3—												
	2984.2	9.3	Ch,	2985.5	9.9	Ro,	2990.9	9.5	Ym,	2993.5	9.5	Ro,
	2997.5	9.6	Ro,	2998.5	9.5	Ro,	3012.3	9.8	Gi,	3012.3	9.3	L,
	3015.5	9.5	Pt,	3028.5	9.5	Pt.						
***184408* S SCUTI—**												
	2990.9	8.2	Ym.									
184929 U LYRAE—												
	3015.3	13.5	Gi.									
185032 RX LYRAE—												
	2984.1	12.6	Ch.									
***185512a* ST SAGITTARII—**												
	2984.1	<12.2	Ch,	3000.2	<11.7	L.						
185634 Z LYRAE—												
	3011.3	10.5	L,	3025.5	10.5	O.						
190108 R AQUILAE—												
	3011.6	8.4	B,	3015.5	9.2	Pt.						
190529a V LYRAE—												
	3025.6	<12.3	Y.									
190967 U DRACONIS—												
	2992.2	12.3	Ch,	3015.5	11.7	Pt,	3031.6	11.6	Hu.			

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
190941 RU LYRAE—												
	3042.5	11.6	Ya.									
190925 S LYRAE—												
	3017.5	<13.7	B.									
190926 X LYRAE—												
	3015.5	9.2	Pt.									
190933a RS LYRAE—												
	2963.2	<12.0	Ch.									
191007a W AQUILAE—												
	2984.2	9.1	Ch,	3015.5	9.7	Pt.						
191007b TY AQUILAE—												
	2984.1	10.6	Ch,	3015.5	10.4	Pt.						
191019 R SAGITTARII—												
	2983.1	8.2	Ch.									
191033 RY SAGITTARII—												
	2969.1	11.7	Ch,	2982.1	<12.5	Ch,	2993.0	<12.5	Ch.			
191350 TZ CYGNI—												
	3015.5	10.8	Pt,	3025.6	11.4	Y.						
191319 S SAGITTARII—												
	3011.2	<13.2	Gi.									
191321 Z SAGITTARII—												
	3011.3	9.9	Gi,	3022.2	10.1	Gi.						
191637 U LYRAE—												
	3015.5	10.4	Pt,	3025.5	10.5	O,	3042.5	10.9	Ya.			
192928 TY CYGNI—												
	2991.1	11.0	Ch,	3015.5	9.4	Pt.						
193311 RT AQUILAE—												
	2992.1	9.2	Ch,	3011.6	9.6	B,	3015.5	10.2	Pt.			
193449 R CYGNI—												
	2991.1	<12.0	Ch,	3006.6	<10.9	Hj,	3011.6	<10.9	Hj,	3019.5	<10.9	Hj,
	3026.7	<10.8	Br,	3031.6	<13.1	B.						
193509 RV AQUILAE—												
	3015.5	12.4	Pt.									
193732 TT CYGNI—												
	3025.6	7.2	Hu.									
194048 RT CYGNI—												
	2991.1	12.0	Ch,	2999.4	11.9	Rk,	3006.6	<9.3	Hj,	3011.4	11.5	Gi,
	3011.6	<10.5	Hj,	3015.5	11.4	Pt,	3017.4	11.3	Rk,	3019.5	<10.0	Hj,
	3023.3	10.6	Gi,	3024.5	9.5	O,	3026.7	<10.8	Br,	3031.5	9.5	O,
	3031.6	9.6	B,	3042.5	9.8	O.						
194348 TU CYGNI—												
	2991.1	12.3	Ch,	2999.4	11.6	Rk,	3017.4	9.9	Rk,	3025.6	8.8	Hu.
194632 χ CYGNI—												
	2970.2	7.2	Ch,	2989.0	8.2	Ym,	2992.1	7.9	Ch,	2996.4	8.0	Rk,
	2997.9	8.9	Jk,	3009.6	8.6	Hj,	3011.5	8.5	B,	3015.5	9.1	Pt,
	3015.5	9.2	Hj,	3015.6	9.4	Lc,	3017.4	8.6	Rk,	3019.5	9.2	Hj,
	3019.6	9.5	Fi,	3021.6	9.6	Br,	3023.6	9.5	Ya,	3024.5	8.9	B,
	3025.5	9.6	O,	3025.6	9.0	Hu,	3031.5	9.7	O,	3042.5	10.0	O.
194604 X AQUILAE—												
	3017.5	13.8	B.									
195116 S SAGITTAE—												
	3011.6	6.1	Mu,	3013.6	5.8	Mu,	3014.6	5.3	Mu,	3022.6	5.7	Mu,
	3026.6	5.9	Mu,	3027.6	6.1	Mu.						
195202 RR AQUILAE—												
	3012.6	<13.8	B.									
195553 NOVA CYGNI #3—												
	3012.5	14.0	B.									
195308 RS AQUILAE—												
	2985.5	9.7	Ro,	2989.0	9.7	Ym,	2991.1	9.8	Ch,	2993.5	9.7	Ro,
	2997.5	9.7	Ro,	3011.5	10.1	Gi,	3012.4	9.4	L,	3015.5	9.8	Pt,
	3017.5	9.6	Pt,	3019.5	9.9	Gd,	3019.5	9.8	Ro,	3023.5	9.6	Pt,

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
195308 RS AQUILAE—Con.												
	3023.6	9.8	Ya,	3027.5	10.2	Ro,	3028.5	9.6	Pt,	3030.5	9.8	Pt,
	3033.5	9.9	Pt,	3034.5	10.0	Ro.						
195849 Z CYGNI—												
	2991.1	9.0	Ch,	3011.4	10.0	Gi,	3015.5	10.9	Pt,	3023.6	11.4	B,
	3024.4	10.9	Gi,	3035.5	<11.6	Ya.						
200212 SY AQUILAE—												
	3012.3	<12.2	L,	3017.5	<13.3	B,	3019.2	12.5	L.			
200514 R CAPRICORNI—												
	3017.2	12.3	Gi.									
200647 SV CYGNI—												
	3025.6	8.6	Hu,	3026.6	8.6	Mu.						
200747 RX CYGNI—												
	3026.6	7.8	Mu.									
200715a S AQUILAE—												
	2990.9	9.4	Ym,	3011.4	10.3	Gi,	3015.5	11.2	Pt.	3015.6	10.6	Lc.
	3022.3	10.9	Gi,	3026.5	10.4	B,	3026.7	<9.8	Br.			
200715b RW AQUILAE—												
	2990.9	8.7	Ym,	3015.6	9.2	Lc,	3026.5	9.4	B,	3026.7	9.2	Br.
200812 RU AQUILAE—												
	3011.6	12.5	B.									
200938 RS CYGNI—												
	2970.2	7.3	Ch,	2992.2	7.2	Ch,	3012.3	7.2	L,	3015.6	7.0	Pt,
	3030.6	7.8	Ya.									
200916 R SAGITTAE—												
	3026.5	9.0	B,	3026.7	8.8	Br.						
200906 Z AQUILAE—												
	3011.3	11.2	Gi,	3015.6	10.6	Pt,	3022.3	9.7	Gi,	3022.5	10.0	B.
201008 R DELPHINI—												
	3012.3	10.7	L,	3012.6	10.6	B,	3015.6	10.8	Pt,	3017.6	10.2	B,
	3038.6	11.6	B.									
201130 SX CYGNI—												
	3012.6	<13.6	B,	3025.6	<13.3	Y,	3043.6	<12.6	Y.			
201121 RT CAPRICORNI—												
	2985.5	7.4	Ro,	3012.3	6.7	L.						
201437a P CYGNI—												
	2970.2	5.2	Ch.									
201647 U CYGNI—												
	2985.5	9.5	Ro,	2993.5	8.7	Ro,	2997.5	8.6	Ro,	2998.5	8.6	Ro,
	3011.5	8.5	Gi,	3015.6	8.4	Pt,	3015.6	8.7	Lc,	3019.5	8.2	Ro,
	3026.6	7.9	Mu,	3027.5	8.0	Ro,	3034.5	8.0	Ro,	3042.5	8.7	Ya.
202622 RU CAPRICORNI—												
	3019.2	13.2	Gi.									
202817 Z DELPHINI—												
	3012.6	<13.6	B.									
202954 ST CYGNI—												
	3017.5	13.2	B,	3043.6	11.7	Y.						
202946 SZ CYGNI—												
	3036.6	9.6	B.									
203226 V VULPECULAE—												
	3015.6	8.4	Pt,	3027.5	8.8	De.						
203611 Y DELPHINI—												
	3025.5	9.3	O,	3038.5	8.7	B.						
203847 V CYGNI—												
	2970.2	8.5	Ch,	2992.2	8.6	Ch,	3011.5	8.0	Gi,	3011.6	8.1	B,
	3025.6	9.6	O,	3036.6	8.7	B.						
203816 S DELPHINI—												
	3023.6	9.8	B,	3031.5	10.3	De,	3038.5	9.4	B.			
204016 T DELPHINI—												
	3015.6	11.0	Pt.									

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
204104 W AQUARII—												
	3012.3	14.1	L,	3022.3	13.8	Gi.						
204215 U CAPRICORNI—												
	3019.2	<13.9	Gi.									
204318 V DELPHINI—												
	3011.4	11.9	Gi,	3011.6	12.1	B,	3023.3	12.5	Gi,	3025.5	<12.0	O.
204405 T AQUARII—												
	2968.1	7.7	Ch,	2984.1	7.6	Ch,	2985.5	7.8	Ro,	2998.5	8.0	Ro,
	3023.5	10.1	Pt,	3036.5	10.9	B.						
204846 RZ CYGNI—												
	3011.4	11.2	Gi,	3023.4	11.5	Gi.						
205017 X DELPHINI—												
	3023.6	10.0	B,	3025.5	9.6	O,	3031.5	10.3	De,	3038.5	10.5	B.
205923 R VULPECULAE—												
	3011.4	9.4	Gi,	3023.3	8.3	Gi,	3023.6	8.2	B,	3025.6	8.0	Hu,
	3031.5	7.5	De,	3038.6	7.3	B.						
210129 TW CYGNI—												
	3043.6	12.0	Y.									
210124 V CAPRICORNI—												
	3019.3	9.1	Gi.									
210221 X CAPRICORNI—												
	3019.3	13.0	Gi.									
210382 X CEPHEI—												
	3043.6	12.5	Y.									
210504 RS AQUARII—												
	2998.3	11.2	L.									
210868 T CEPHEI—												
	2959.0	10.0	Jk,	2970.2	10.2	Ch,	2998.0	9.8	Jk,	2998.3	10.2	L,
	3023.6	8.8	Pt,	3024.7	9.1	L,	3032.6	8.8	Fi,	3042.5	8.0	Ya,
	3044.6	8.4	Cg.									
211614 X PEGASI—												
	3012.3	11.2	Gi,	3024.3	11.8	Gi,	3043.6	12.0	Y.			
213244 W CYGNI—												
	2989.0	7.2	Ym,	2998.3	6.2	L,	3019.4	5.7	L.			
213678 S CEPHEI—												
	3022.5	8.7	Gi,	3023.5	8.7	B,	3023.6	9.6	Pt,	3026.7	9.7	Br,
	3032.6	9.8	Fi.									
213843 SS CYGNI—												
	2959.0	9.6	Jk,	2963.1	10.3	Ch,	2985.5	11.2	Ro,	2989.0	11.2	Ym,
	2990.0	12.0	Ym,	2990.9	11.8	Ym,	2992.2	11.9	Ch,	2996.4	12.1	Rk,
	2996.7	<10.9	Hj,	2997.5	11.2	Ro,	2998.0	<11.3	Jk,	2998.3	12.0	L,
	2998.5	11.0	Ro,	2999.0	<11.3	Jk,	2999.4	11.6	Rk,	3000.2	11.7	L,
	3002.4	11.9	Rk,	3004.4	11.5	Rk,	3010.2	11.5	L,	3011.3	11.7	L,
	3011.5	11.5	Gi,	3011.6	11.6	B,	3011.7	<11.3	Hj,	3012.4	11.5	Gi,
	3012.4	11.6	L,	3012.6	11.6	B,	3014.6	8.4	Hj,	3015.3	8.5	Gi,
	3015.6	8.3	Pt,	3016.5	8.7	O,	3016.6	8.6	B,	3017.3	8.7	Gi,
	3017.4	8.7	Rk,	3017.6	8.7	Pt,	3018.4	9.0	Rk,	3019.3	9.5	Gi,
	3019.4	8.8	L,	3019.5	9.5	Gd,	3019.5	9.4	Ro,	3019.6	9.2	Y,
	3019.6	9.5	B,	3020.4	9.7	Rk,	3021.4	9.9	Rk,	3022.2	10.4	L,
	3022.4	10.4	Gi,	3022.4	10.2	Rk,	3022.5	10.3	B,	3023.4	11.1	Gi,
	3023.4	10.8	L,	3023.5	11.1	B,	3023.5	10.5	Pt,	3023.6	11.2	Hj,
	3023.6	10.6	Ya,	3024.4	11.2	Gi,	3024.4	12.0	Gd,	3024.4	11.3	Rk,
	3024.5	11.2	B,	3024.5	11.0	O,	3025.5	11.6	O,	3025.6	11.9	Hu,
	3026.5	11.2	B,	3026.6	<10.9	Br,	3026.6	11.6	Mu,	3028.5	11.5	Pt,
	3029.5	11.6	B,	3030.5	11.5	B,	3030.5	11.6	Pt,	3031.5	11.2	O,
	3031.6	11.1	B,	3032.5	10.9	O,	3033.5	11.6	Pt,	3034.5	11.7	Pt,
	3034.6	11.2	B,	3036.5	11.5	B,	3038.5	11.2	B,	3043.5	11.8	Ya,
	3043.6	12.0	Y.									
213937 RV CYGNI—												
	3025.6	7.0	Hu.									

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
214024 RR PEGASI—												
	3022.6	<13.5	B.									
215605 V PEGASI—												
	3016.6	<10.9	Lc,	3022.6	10.0	B.						
220412 T PEGASI—												
	3017.3	<13.5	Gi,	3022.3	13.2	L,	3022.7	<13.5	B.			
220613 Y PEGASI—												
	3012.4	12.5	Gi,	3024.3	12.9	Gi,	3031.5	<12.0	De,	3031.6	<12.8	B.
220714 RS PEGASI—												
	3012.4	11.8	Gi,	3024.3	12.1	Gi,	3031.5	12.5	De,	3031.6	12.6	B.
222129 RV PEGASI—												
	3019.6	12.5	B,	3030.6	12.6	B.						
222439 S LACERTAE—												
	3011.6	11.4	Gi,	3012.3	11.7	L,	3024.4	11.6	Gi,	3026.6	12.2	B,
	3038.6	12.4	B.									
223841 R LACERTAE—												
	3012.4	12.4	L,	3015.4	12.4	Gi.						
225914 RW PEGASI—												
	3019.6	11.7	Y,	3023.6	12.3	B,	3026.7	<10.0	Br,	3031.6	<12.1	De,
	3038.6	12.9	B.									
230110 R PEGASI—												
	2998.0	<10.9	Jk,	3019.6	11.8	Y,	3026.7	<10.5	Br.			
230759 V CASSIOPEIAE—												
	3019.5	11.2	Gi,	3019.7	12.0	B,	3023.7	11.5	Pt,	3027.5	11.2	Ro,
	3036.6	10.7	B.									
231425 W PEGASI—												
	2998.3	10.2	L,	3012.4	9.6	L,	3025.6	8.9	Hu.			
231508 S PEGASI—												
	3023.7	12.3	Pt.									
233335 ST ANDROMEDAE—												
	2955.1	<11.0	Ch,	3023.7	8.9	Pt,	3025.6	8.9	Hu,	3036.6	9.2	B.
233815 R AQUARII—												
	2968.2	9.9	Ch,	2992.2	9.5	Ch,	3023.7	8.2	Pt,	3027.5	8.4	Ya.
233956 Z CASSIOPEIAE—												
	3006.7	10.6	Ml,	3011.5	10.6	B,	3019.7	10.2	B,	3024.5	10.4	B,
	3030.6	10.3	B.									
235053 RR CASSIOPEIAE—												
	3019.5	11.6	Gi,	3026.6	11.5	B.						
235209 V CETI—												
	3019.3	<13.6	L,	3022.4	<13.1	Gi.						
235350 R CASSIOPEIAE—												
	3012.6	7.5	B,	3015.4	7.8	Gi,	3036.6	8.0	B.			
235525 Z PEGASI—												
	3023.7	13.0	Pt.									
235715 W CETI—												
	3015.3	13.6	Gi.									
235855 Y CASSIOPEIAE—												
	3019.5	12.8	Gi,	3019.7	13.4	B,	3036.6	12.1	B.			
235939 SV ANDROMEDAE—												
	3013.5	11.5	B,	3023.7	11.8	Pt,	3036.6	11.8	B,	3043.6	11.8	Y.

Total Observations: 904. Stars Observed: 249. Observers: 23.

Ginori "Gi." Godfrey "Gd." Hoerl "Hp." Hunter "Hu" Miss Jenkins "Jk." Lacchini "L," Lacy "Lc," McAteer "M," Merrill "Ml," Mundt "Mu," Olcott "O," Peltier "Pt," Reesinck "Rk," Rhorer "Ro," Yalden "Ya," Yamamoto "Ym," and Miss Young "Y."

ARVILLE D. WALKER, Recording Secretary.

GENERAL NOTES.

Henrietta S. Leavitt, of the Harvard College Observatory, died on December 12. Since 1902 she had been engaged in the study of the photographic brightness of the stars and the distribution and periods of variable stars.

Mr. Lewis J. Boss of North Scituate, R. I., is at present trying to find periods for the two irregular variables α Orionis (Betelgeuse) and α Cassiopeiae. He is using a selenium cell on the 8½-inch equatorial of Mr. F. E. Seagrave's observatory at North Scituate. On each clear night he spends about 4½ to 5 hours on each star, recording an observation every fifteen minutes. α Orionis at the present time proves to be a most interesting object. Mr. Boss is a young man, a nephew of the late Professor Lewis Boss, former director of the Dudley Observatory, and is very enthusiastic in his astronomical work.

The American Astronomical Society will hold its next meeting at Yerkes Observatory, Williams Bay, Wis., the week following next Labor Day. The next winter meeting will be held at Vassar College, Poughkeepsie, N. Y., and the summer meeting of 1923 probably at the Mount Wilson Observatory, near Pasadena, Cal.

Syracuse Astronomical Society.—The officers re-elected for the coming year are: President, Professor E. D. Roe, Jr.; vice president, Dean W. P. Graham; secretary, Mr. A. L. Wallon; treasurer, Mr. Morgan R. Sanford.

The American Members of the Committee on Double Stars of the Astronomical Union of the Conseil International de Recherches will hold a meeting at Dearborn Observatory on February 6, 1922, for the discussion of matters to be submitted at the meeting of the Union at Rome in April. The American members of this committee are: R. G. Aitken, chairman; W. J. Hussey, G. Van Biesbroeck, and Philip Fox. The death of Eric Doolittle deprived the American membership of one of its most able representatives.

Asteroid (907) Barnardina.—We have been requested, in behalf of Professor Barnard, to state that the asteroid No. 907 (1918 U E) was named by Professor Max Wolf, its discoverer, in memory of the late Mrs. Barnard and not for himself.

Dallas Astronomical Society.—The Dallas Astronomical Society held its regular monthly meeting last night at the Chamber of Commerce. This was the third meeting of the society, and it was definitely decided to make it a permanent organization. Members of the society elected the following officers: Dr. A. D. Laugenour, president; E. F. McIntyre, first vice president; H. E. Webb, second vice president, and H. B. Thevenet, secretary and treasurer. Dr. David Lefkowitz, Prof. L. F. Fouts and M. F. Horton were elected directors.

The society has a membership of forty-four, of which nine were elected last night. It was decided to have the regular monthly meetings on the fourth Saturday of every month.

The society is corresponding with several lecturers and plans to bring them to Dallas in the near future. A lecture was given last night by E. F. McIntyre on "Telescopes."—*Dallas Morning News*, Dec. 30, 1921.

Dimensions of Messier 3.—The discovery of a short-period variable star at a distance of 25′ from the center of Messier 3 is announced in Astronomische Nachrichten **214**, 71, 1921, by Larink, who considers the star a member of the neighboring globular cluster, although its period, about 3.25 hours, is much shorter than that of any of the variables for which Professor Bailey has determined periods. By adopting 0″.00007 as the parallax of the cluster (M. W. Contr. 152), we find that the new variable, if a member of the system, would be at least 100 parsecs (325 light years) from the center, and in consequence the possible dimensions of a globular cluster would be nearly double the value formerly assigned.

Harvard Photographs confirm the variability of Larink's star and the abnormal shortness of its period. Measures of the brightness on ten plates, selected to show maximum amplitude, give a range from 14.6 to 15.4, when the photographic standards derived from Mount Wilson plates are used. The median brightness is half a magnitude greater than the average median value, 15.50±0.01, of the 110 other variables of known period in Messier 3 (M. W. Commun. 47). The new variable, therefore is probably not an outlying member of the cluster. If, as appears likely, it is an isolated cluster-type variable, its distance from the galactic plane is of the order of 10,000 parsecs, which is considerably greater than the distance so far determined for any non-cluster star.

Cambridge, Mass., U. S. A., December 10, 1921.

HAROLD SHAPLEY.

Harvard College Observatory Bulletin 761.

The Glacial Epochs.—Many attempts have been made to account for such epochs in the past history of the earth, some resting an astronomical bases and others depending upon changes in the composition of the earth's atmosphere. Among the former are Croll's theory based upon the changing eccentricity of the earth's orbit and Drayson's theory depending on changes in the obliquity of the ecliptic. A recent number of "Die Naturwissenschaften" contains a new astronomical theory by F. Noelke of Bremen. This new theory assumes that the solar system, in its journey through space, passes through nebulous regions. When in such a region some of the sun's heat is absorbed by the nebular material and the mean temperature of the earth lowered in consequence, thus bringing about a glacial epoch. It will be interesting to see how this new theory will fare when examined by those especially interested in the problem.

Calendar Reform.—The Liberty Calendar Association of America, Minneapolis, Minn., sends us the following information:

Our campaign in favor of the adoption of the Liberty Calendar is progressing very nicely. In fact, we feel that we are making quite rapid and very substantial progress.

The International Chamber of Commerce at its meeting held in London, the 27th of last June, passed a good strong resolution in favor of an effort to improve the calendar. Through a friend living in Glasgow, Scotland, our plan

was presented to all the Bishops of the Catholic and Episcopalian churches in the British Isles and also to Pope Benedict at Rome.

The result is that a dispatch to the Associated Press from Rome dated October 13th states that "The Vatican has announced that a conference of astronomers will take place in Rome next April under the presidency of Cardinal Mercier with the object of reforming the calendar and fixing Easter."

A convention will doubtless be held in Washington, D. C., within the next few months to give the whole matter of calendar reform careful consideration.

Résumé of Sun-spot Observations at Mt. Holyoke College, 1921.

		North of Equator		South of Equator			
Month	No. of Obs.	No. Groups	Av. Lat. °	No. Groups	Av. Lat. °	Av. No. at One Obs.	New Groups
Jan.	17	3	+12.0	5	— 8.2	1.59	8
Feb.	14	1	+15	7	— 7.4	1.79	7
Mar.	19	6	+12.8	4	— 6.8	2.00	10
Apr.	16	6	+13.5	4	— 8.2	2.50	9
May	19	3	+ 8.7	2	— 9.5	1.11	4
June	14	5	+12.4	4	— 6.2	1.93	9
Sept.	10	2	+ 9.5	2	— 3.5	1.60	4
Oct.	19	6	+ 8.8	1	—18	1.47	7
Nov.	13	2	+ 8.5	1	— 5	0.92	3
Dec.	15	4	+13.0	2	— 9.0	1.33	6
Totals	156	38		32			67

Average number at one observation	1.63
Average latitude of groups north of equator	+10°.5
Average latitude of groups south of equator	— 7°.4
Number of days without spots	20

The method of observation was the same as that followed in previous years. An especially fine group of spots passed the sun's central meridian on May 14, and was followed by a brilliant aurora in the evening.

ALICE H. FARNSWORTH.

John Payson Williston Observatory.

Nova Puppis.—No trace of the nova announced in Bulletin 760 is found on a plate made with the 16-inch Metcalf Telescope on November 24, 1921, which shows stars fainter than magnitude 15.0. The decrease in brightness has therefore been greater than eight magnitudes.

Harvard College Observatory Bulletin 761.

A Fourth Variable of R Coronae Type.—From visual observations submitted by Baldwin, Skjellerup, and Long, and from Harvard photographic observations, it appears that the southern variable star S Apodis, *145971*, undergoes variations in light similar to those of the peculiar variables R. Coronae Borealis, 154428, RY Sagittarii, *191033*, and SU Tauri, 054319. The spectrum of SU Tauri is unknown. The spectra of R. Coronae Borealis and RY Sagittarii are given ac Gp in the Henry Draper Catalogue, but the S Apodis, according to Miss Cannon, belongs to the uncommon class R3. The visual range is from 10.0 to fainter than 13.4; the photographic range is from 10.6 to 15.8. The last minimum occurred during October and November, 1919. The star appears to be decreasing in brightness at the present time.

Harvard College Observatory Bulletin 761.

Drake University Municipal Observatory.—Prof. D. W. Morehouse has kindly furnished us with the following program of the dedication of the Drake University Municipal Observatory which was held on November 5. 1921. The dedicatory address by Dr. Moulton and an address descriptive of the Observatory by Dr. Morehouse are given in the earlier pages of this number of POPULAR ASTRONOMY.

Dr. Morehouse writes: "The Observatory is proving more than I had hoped for in the way of attracting the interest of the people of Des Moines."

May many cities follow the example of Des Moines!

PROGRAM, DEDICATION DRAKE UNIVERSITY MUNICIPAL OBSERVATORY,
SATURDAY MORNING, NOVEMBER 5, 1921.

PRESIDING—Hon. Lafe Young, Sr., Editor of *The Des Moines Capital.*
INVOCATION—Dr. Charles S. Medbury, Pastor of the University Church of Christ.
REPRESENTING THE COLLEGES AND UNIVERSITIES—Dr. Walter A. Jessup, President of The State University of Iowa.
RERESENTING THE PUBLIC—Hon. Harvey Ingham, Editor of *The Des Moines Register.*
THE ATTITUDE OF THE PRESS—Mr. Austin P. Haines, Editor of *The Des Moines News.*
MUSIC—Suite in C Major for Violincello Solo, Mr. Wallingford Riegger, of Drake University Conservatory of Music.
DEDICATORY ADDRESS—*Larger Worlds,* Dr. Forest Ray Moulton, Professor of Astronomy, The University of Chicago.
DEDICATION OF OBSERVATORY—Councilman Harry B. Frase, representing the city.
ACCEPTANCE FOR TRUSTEES—Mr. D. H. Buxton, President of the Board of Trustees of Drake University.
REPRESENTING DRAKE UNIVERSITY—Dr. Daniel W. Morehouse.

Annals of the Observatory at Leiden.—Parts 1 and 2 of Volume XII of the "Annalen van de Sterrewacht te Leiden" have recently come to hand, having been published in 1918 and 1919 respectively. The first contains a memoire by W. de Sitter on "Outlines of a new mathematical theory of Jupiter's satellites," the second a memoire by Dr. A. J. Leckie entitled "Analytical and numerical theory of the motions of the orbital planes of Jupiter's satellites."

Bulletin of the Astronomical Institutes of the Netherlands.—This is a new astronomical journal, intended to serve the needs for immediate publication of communications from the Observatories at Leiden and Utrecht, the Kapteyn Astronomical Laboratory at Groningen, the Heliophysical Observatory at Utrecht and the Astronomical Institute at Amsterdam. The first number was issued November 30 and the second December 23, 1921. The last mentionel contains the report of the director of the Observatory at Leiden from May 1, 1919, to August 31, 1921. Prof. Dr. W. de Sitter was appointed director of the Leiden Observatory on April 30, 1919, succeeding the late Prof. E. F. van de Sande Bakhuyzen, who died on March 3, 1918.

The Northern Galaxy.—Dr. A. Pannekoek of the observatory at Leiden, Holland, has recently published a series of naked eye observations of the northern portion of the Milky Way. The observations, made at intervals during the years 1893-1913, represent a great amount of careful work. The publication is divided into three portions, a minute description of the various regions, the brightness of the various parts expressed in scale values in sections according to galactic latitude and longitude, and finally carefully drawn charts with the regions of equal brightness connected by isophotal lines. A similar

study of the southern galaxy would be of great value so that the entire Milky Way as an optical phenomenon could be pictured and used as a basis for comparison with photographic results, in order that a proper theory of its structure as a whole might be secured.

Spectrum of SU Tauri, 054319.—A photograph of the spectrum of SU Tauri, which is a variable of the R Coronae class, was taken on December 29, 1921, with the 16-inch Metcalf Telescope. The spectrum is of the solar type, but the dispersion is not sufficient to show whether the peculiarities common to the spectra of R Coronae Borealis and RY Sagittarii are also present. The spectrum of the similar variable, S Apodis, was reported in H. B. 761.

Harvard College Observatory Bulletin 762.

Cambridge, Mass., U. S. A., January 11, 1922.

Variations in Spectrum and Light of B. D. + 11° 4673.—A letter received at this Observatory from Dr. Paul W. Merrill of the Mount Wilson Observatory states that "bright helium lines began to develop in the spectrum of the star B. D. + 11°4673 about August 1920 and by June 1921 were very strong." The helium lines were dark in 1915 when observed by Merrill at the observatory of the University of Michigan. Miss Cannon has examined seven spectrum plates made during the interval 1893 to 1912 and finds no change in the emission lines of hydrogen.

Lundmark has called attention to the probable variability of the star as shown by the estimates of magnitude in star catalogues (A. N. **213**, 93, 1920). From an examination of 51 Harvard photographs covering an interval of 15 years, Miss Wells finds that the star appears to be slowly decreasing in brightness. It is now about three-tenths of a magnitude fainter than in 1906.

The star is of spectral importance as an intermediate, in light and spectral peculiarities, between novae and other kinds of variables. Its spectrum belongs to the peculiar class represented by P Cygni.

Harvard College Observatory Bulletin 762.

Cambridge, Mass., U. S. A., January 11, 1922.

New Period for U Cephei.—In 1903 Chandler concluded that his mean period, $2^d.4928761$, of the eclipsing binary U Cephei satisfactorily represented all observations up to that date with the exception of a single estimate by Schwerd in 1828. Mrs. Shapley's discussion of the light-elements, which was based largely on Wendell's work at Harvard, showed that a rather sudden increase of two seconds in the length of the period occurred in 1905 (Ap. J. **44**, 51, 1916). Dugan's observations and discussion have verified the increased length of period (Princeton Contr. 5, 1920).

Wendell's work has been continued in recent years with the Harvard polarizing photometer by Mr. Campbell, whose observations on December 30, 1921, of both branches of the light curve at the principal eclipse, give a heliocentric minimum at $13^h\ 12^m$ G. M. T. He deduces a new mean period of $2^d.492901$, which represents satisfactorily all available observations since the abrupt change in 1905.

There is no indication of a continuously increasing period in the observations made since the discovery of the star's variability in 1880. But in addition

to the conspicuous change of two seconds in the period, about 17 years ago, there are oscillations of a few minutes' amplitude in the time of primary minimum, one of which appears to have a period of ten or fifteen years.

Harvard College Observatory Bulletin 762.

Cambridge, Mass., U. S. A., January 11, 1922.

Newcomb-Engelmann's Populaere Astronomie, 6th revised edition. (Wilhelm Engelmann, Leipzig. Price 110 marks plus export tax.)

This volume, which has just been received, is fully up to the standard set in the former editions. The new editor, Professor Ludendorff, and his collaborators have succeeded in bringing in the most recent advances in astronomy without unduly increasing the number of pages, which now number 900. The reviewer knows of no book covering the whole field of astronomy which is on a par with it. It can be recommended without reservation as well-balanced, up-to-date and authoritative to anyone who can read German and who desires a non-technical exposition of the fundamentals of the science. Its 240 illustrations add much to the attractiveness of the volume.

"A prophet is not without honor save in his own country." Simon Newcomb wrote his delightful *Popular Astronomy* in 1877. He presented the facts and theories of astronomy in such a fresh and masterful way that the volume is still worth reading even though many portions are of value only as ancient history. The book made such an impression abroad that a German translation was issued in 1881 and revised editions of the translation appeared in 1892, 1905, 1911, 1914, and this last one at the end of 1921. While it is a great tribute to Newcomb that these many revisions have been published abroad, yet it is unfortunate that many who can read only English must still take refuge in the original edition published 45 years ago. It would be a distinct service to astronomy, and of great value to many who would delight in its pages, if arrangements could be made to translate this last German edition back into English.

Theory of Planetary Motions by Dr. Paul Meth, 2nd edit., 54 pp., 20c, **The End of the World in Legend and Science,** by Ziegler and Oppenheim, 122 pp., 35c, and **Observation of the Heavens with the Naked Eye,** by F. Rusch, 163 pp., 80c, are three bookletts just off the press of B. G. Teubner of Leipzig and Berlin. They can be recommended to anyone who can read German and who desires a brief and interesting statement of the subjects treated in untechnical language.

Observer's Handbook for 1922.—For many years *The Observatory*, published in England, has issued as an extra number a handbook entitled "The Companion to The Observatory," which has been found very useful to amateur astronomers. Last year *The Observatory* found it necessary on account of the expense to discontinue the publication of the "Companion." This year the place of the "Companion" is supplied by the "Observer's Handbook," published by the British Astronomical Association. The data given are much the same as those furnished by the "Companion" and a few new items are added. The wants of observers in southern latitudes have been especially borne in mind in the preparation of the "Handbook."

Non-members of the British Astronomical Association may obtain the

"Handbook" from Eyre and Spottiswoode, Ltd., His Majesty's printers, London, England. Price 2 shillings.

For a number of years the Royal Astronomical Society of Canada has published a similar "Observer's Handbook," edited by Professor C. A. Chant, at Toronto, Canada. This may be had for 25 cents.

Moving Clusters.—An interesting monograph on this subject by Nils H. Rasmuson of the Lund Observatory has just been received. He considers all the well-known moving clusters, such as the Taurus group, the Ursa Major group, the Perseus group and others. Some of his results, given in part in his own words, are as follows: 1. The capacity of forming moving clusters seems to be confined especially to stars of great mass of spectral types B and A, mixed sometimes with a small number of giant stars of later types. The fainter stars originally connected with the cluster have had greater chances of being lost to the cluster by collision with other clusters because of their smaller mass. 2. The mean absolute magnitudes of the stars in the moving clusters are —0.5 for B0 - B5 stars; +0.9 for B8 - B9 stars; +1.5 for A stars (Absolute magnitude being defined as the magnitude a star would have if its parallax were 0".1). 3. The motion of the clusters is approximately parallel to the plane of the Milky Way. 4. The density of stars in the Ursa Major, Perseus and Scorpio-Centaurus clusters is about 0.001 per cubic parsec while the density in the Taurus cluster is about 150 times as great. 5. The apparent motion of the B-star clusters is directed nearly toward the antapex of the solar motion. The motions with respect to the stars as a whole are from 5 to 6 kilometers per second and may therefore be considered practically at rest in space.

Recording Wireless Signals.—The Elgin Observatory of the Elgin National Watch Company, at Elgin, Illinois, on Armistice Day, November 11, 1921, obtained its first chronographic record of the French scientific radio time signals from the LaFayette Station, Bordeaux, France, at a distance of 4,400 miles. The recording apparatus devised by Frank D. Urie is entirely automatic, the incoming radio signals controlling the movement of the chronographic pen. The receiving aerial is a small one consisting of a single wire 180 feet long and 30 feet high. (*Science*, January 20. 1922.)

Aid to Russian Astronomers.—During the last session of the meeting of the American Astronomical Society, held at Swarthmore, December 29-31, the members of the Association contributed personally a sum of $150 to be sent to Professor A. Belopolsky and Madame Ceraski. The major portion of this sum was sent to Dr. Belopolsky asking him to use such part of it as he could for himself and those dependent upon him and the remainder to be distributed to such Russian astronomers as his judgment dictated. The remainder was sent to Madame Ceraski. The money was put in the hands of a committee consisting of Dr. Benjamin Boss of Albany, Dr. H. C. Wilson of Northfield, and Mr. John A. Miller of Swarthmore. With this contribution was sent the warmest personal regards to Dr. Belopolsky and Madame Ceraski in particular and to the Astronomical Fraternity in general.

Einstein's Theory.—T. J. J. See, in the following "Letter to the Editor", attempts to demolish the Einstein Theory by showing that it violates the law of the "Conservation of Energy."

LETTER TO THE EDITOR.

In the Scientific Journals I notice much vague discussion of Einstein's Theory, without any indication that Einstein's Theory really violates the *Conservation of Energy*, and therefore is invalid, and must be definitely rejected. Here is the proof.

1. The whole of Einstein's speculation reposes on Gerber's formula for the Potential (*Zeitschrift für Mathematische Physik*, Band XLIII, 1898, pp. 93-104):

$$V = k^2 mm^1/r(1 - dr/cdt)^2 = (k^2 mm^1/r)[1 + 2dr/dt + (3/c^2)(dr/dt)^2 + \ldots] \quad (1)$$

2. Now in his great *Treatise on Electricity and Magnetism*, 1873, Section 856, Maxwell gives a profound and conclusive discussion of Weber's Fundamental Electrodynamic Law of 1846, of which the Potential is:

$$V = (k^2 mm^1/r)[1 - (1/c^2)(dr/dt)^2] \quad (2)$$

3. Maxwell answers the objections which had been made to Weber's Law by Helmholtz, Lord Kelvin, and Tait so thoroughly that they give up the claim that it did not conform to the Conservation of Energy. The Analysis of Maxwell was afterwards approved by the great French mathematicians Bertrand, Tisserand, and Poincaré, and therefore we know this formula (2) is valid in the physical theory of the Universe. In fact formula (2) represents the Potential due to wave-field, and thus points to the Wave-Theory of Physical Forces.

4. But as formula (1) is inconsistent with formula (2) we see immediately that the Gerber formula must be definitely rejected. Hence the whole of Einstein's Theory falls to the ground.

T. J. J. SEE.

Naval Observatory, Mare Island, California.
January 14, 1922.

New Comet discovered January 20.—After the forms for this issue of POPULAR ASTRONOMY were made up, the following announcement was received of a comet discovered at the Cape of Good Hope on January 20. The comet is very faint and too far south for northern observers to secure satisfactory observations. No statement is given as to the direction of its motion.

"Brussels cables very faint comet discovered January twenty at Cape position January twenty four decimal three nine eight eight Greenwich mean time ascension nine hours fifty four minutes thirty and nine tenths seconds south thirty three degrees forty six minutes. Harlow Shapley. Cambridge, Mass., January 28-29."

The position thus given for the comet is: R. A. $9^h\,54^m\,30^s.9$; Dec. $-33°\,46'$; in the southern constellation Antlia, which contains no bright star. It is above our horizon when near the meridian.

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HERBERT C. WILSON, Editor,
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